SAE Journal

AUGUST 1954

IN THIS ISSUE . . .

NEW TOLERANCES reflect machining variations more realistically, get nod from SAE drafting groups . . . page 17

FAVORABLE RESIDUAL STRESS produced by shot peening adds to fatigue life . . . page 24

IMAGINARY FLIGHTS over scheduled runs furnish convincing proof of the jet airliner's practicality . . . page 30

TURBINE-POWERED CAR gets body and chassis built to stand the gaff of its power-packed engine . . . page 40

THRUST REVERSER can brake jet planes just as reverse-pitch props stop piston engine craft . . . page 75

Published by The Society of Automotive Engineers

WHICH IS HOTTER?

Flowing molten lava?

Inside a car's engine?

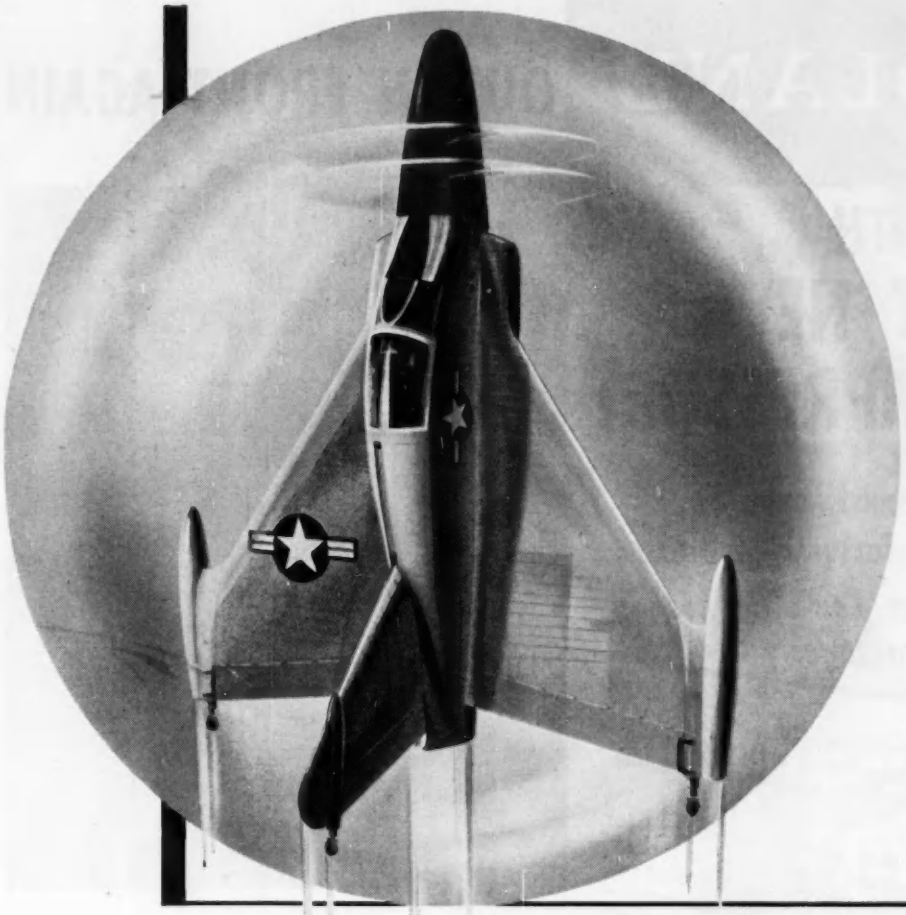
Answer: When combustion occurs, the temperatures within the cylinders of an engine frequently go as high as 4800° Fahrenheit...more than *three times as hot* as flowing volcanic lava!

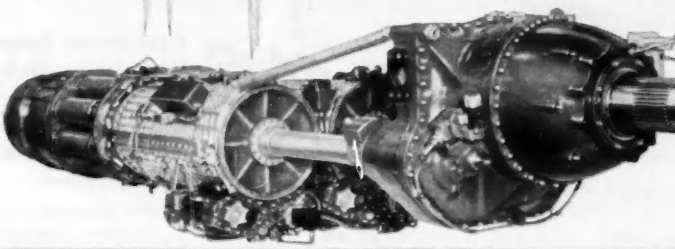
The advantages of chrome plated piston rings in this area of greatest heat, highest pressure and poorest lubrication have been recognized by automotive engineers everywhere...and

34 out of **36** engine manufacturers specifying chrome rings use **Perfect Circle**

The Standard of Comparison

* **The application of solid chrome plating to piston rings, as perfected by Perfect Circle, more than doubles the life of pistons, cylinders, and rings. Complete performance data will be sent upon request. The Perfect Circle Corporation, Hagerstown, Indiana; The Perfect Circle Co., Ltd., Toronto, Ontario.**





The Convair XFY-1's power plant is an Allison T40 turbo-prop engine, using some 80 New Departure **ball** bearings in 30 sizes.

Here, New Departures mean precise location of moving parts . . . preserve shaft alignment and accurate pitch-line contact of gears.

BEARINGS for a "Pogo" Pilot

Vertical take-off! Tailfirst landing! Fighter action! It's the Navy's newest—the Convair XFY-1 "pogo stick."

In its Allison T40 turbo-prop engine, some 80 New Departure **ball** bearings assure positive positioning of moving parts. And in the hub mechanisms of the Curtiss-Wright Turbolectric propellers, New Departures carry heavy loads.

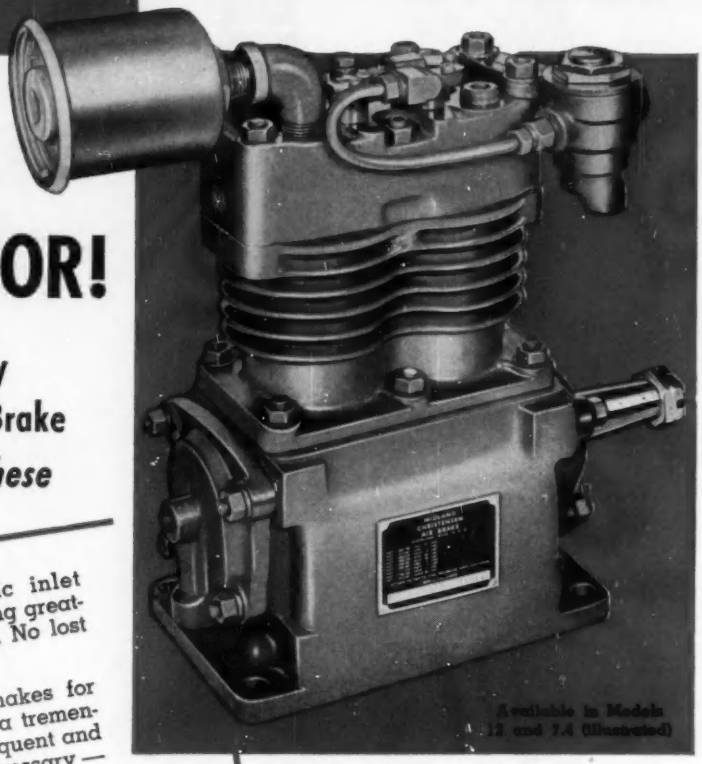
Throughout defense and industry, you'll find New Departure **ball** bearings ideal for countless applications. So whatever your bearing problem, *talk with your New Departure engineer . . . now!*

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Plants also in Meriden, Connecticut, and Sandusky, Ohio
In Canada: McKinnon Industries, Ltd., St. Catharines, Ontario

MIDLAND OUT IN FRONT AGAIN

WITH GREAT NEW AIR COMPRESSOR!



Newly-Designed Model By Veteran Manufacturer of Brake Systems *Gives You All These Advantages*

Greatest Efficiency: Patented automatic inlet valves built into cylinder head, permitting greatest efficiency possible in a compressor. No lost piston travel.

Fastest Recovery: Valve mechanism makes for fastest possible recovery of pressure, a tremendously important advantage where frequent and repeated brake applications are necessary — such as in dense city traffic or on steep downgrades.

Minimum Oil Consumption: Lack of high vacuum on suction stroke — another result of Midland's patented automatic inlet valves — reduces oil consumption to minimum, practically eliminates carbon formation.

Governor Mounting: Governor located on side of compressor simplifies installation. (Governor can be remotely installed if need be.)

Cooler Operation: Inlet valves remain open so long as tank is at desired pressure, allowing atmospheric air to circulate through compressor for cooler operation.

PLUS

- ***Ball Bearing Mounted Crankshaft***
- ***Full High Pressure Lubrication System***
- ***Less Weight***
- ***Operates with Less Horse Power***
- ***Low Cost Maintenance***
- ***Service Features:***

Unloading mechanism needs no adjustment. Replaceable automotive precision type connecting rod bearings. Factory rebuilt units available for service.

For complete details, see your nearest Midland dealer—or write factory direct.

THE MIDLAND STEEL PRODUCTS COMPANY
3641 E. Milwaukee Ave. • Detroit 11, Michigan
Export Department: **38 Pearl Street, New York, N. Y.**

Those Who Know Power Brakes Choose **MIDLAND!**

GO MIDLAND — AND STOP SAFELY!

SAE JOURNAL, August, 1954, Vol. 62, No. 8. Published monthly by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 29 West 39th Street, New York 18, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter. September 15, 1948, at the Post Office at Lancaster, Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1948. Additional entry at New York, N. Y.

Precision "O" Rings make these Quick-Connect couplings leak-proof!

Hydraulic, pneumatic and other fluid lines can be connected or disconnected quickly, easily and safely with the two-way shut-off couplings made by **The Hansen Manufacturing Company** of Cleveland. When connected the Hansen coupling permits a free flow through it—and a **Precision "O" Ring** makes the vital seal which insures a long life of leak-proof service.

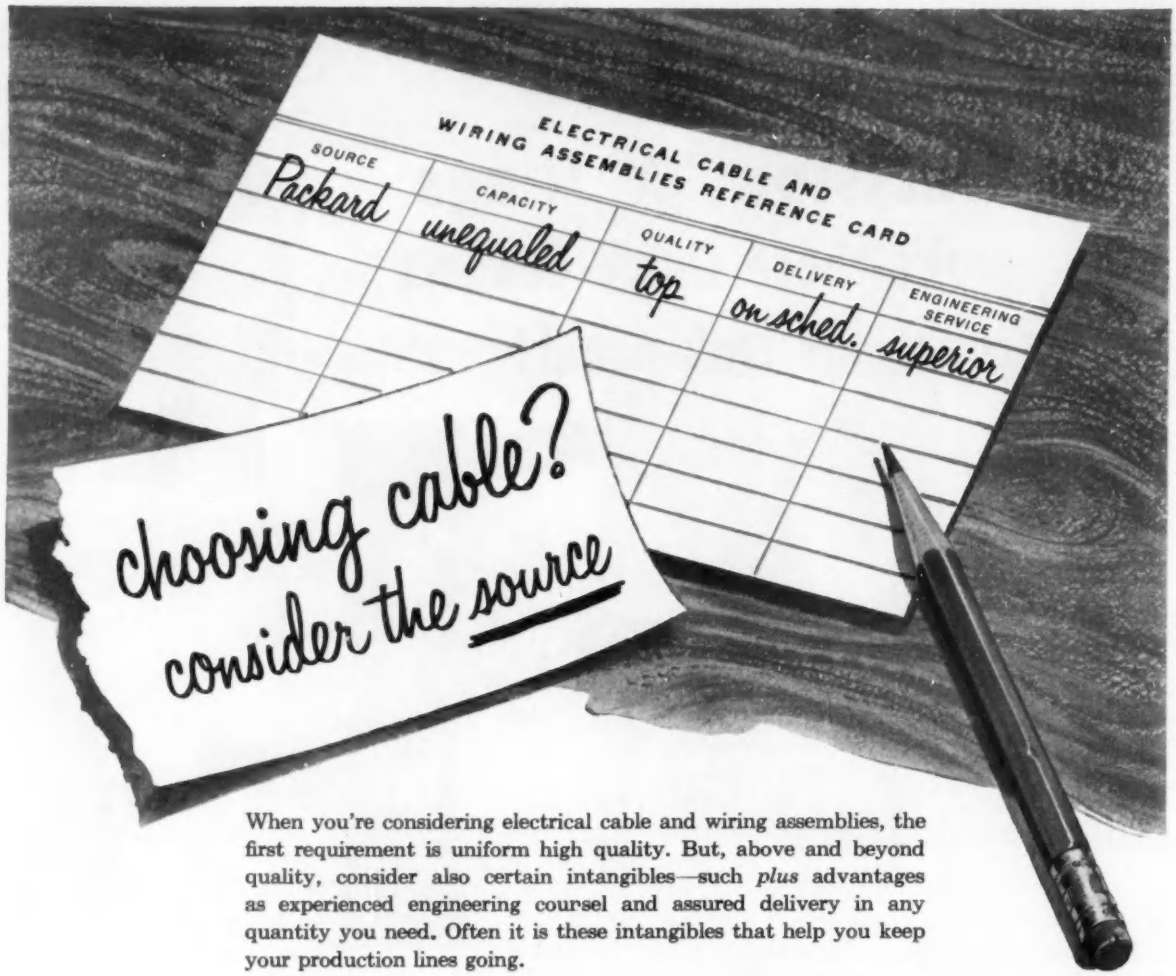
Everywhere **Precision "O" Rings** are doing a big job, carefully inspected, high quality, tough, compression molded, they lick leakage! Let us help you.

FREE—Write for your personal copy of our Handbook on "O" Rings.

Precision Rubber Products CORPORATION

"O" Ring and Dyna-seal® Specialists

3110 Oakridge Drive, Dayton 7, Ohio Canadian Plant at: Ste. Thérèse de Blainville, Québec



When you're considering electrical cable and wiring assemblies, the first requirement is uniform high quality. But, above and beyond quality, consider also certain intangibles—such *plus* advantages as experienced engineering counsel and assured delivery in any quantity you need. Often it is these intangibles that help you keep your production lines going.

Consider Packard as a source

Product *quality*? The wide choice of Packard, by America's foremost manufacturers of automotive vehicles, aircraft and appliances, is your answer.

Capacity and delivery? Packard is equipped to produce more than 7,000,000 feet of finished cable, and 800,000 wiring assemblies, *daily* . . . and to maintain delivery schedules unfailingly.

Engineering service? A large staff of Packard engineers is ready to serve you at any time, at any place. Call on them—the earlier, the better, preferably while your new product or model is still on the drafting board. Our engineering counsel has often effected important savings in assembly costs.

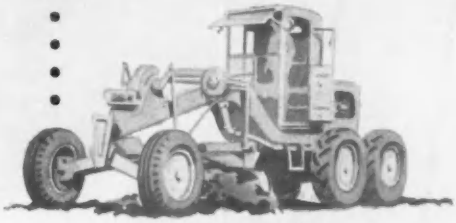
Packard
REG. U.S. PAT. OFF. TRADE MARK

Packard Electric Division • General Motors Corporation • Warren, Ohio

AUTOMOTIVE, AVIATION AND APPLIANCE WIRING

Ross STEERS THEM ALL

TRUCKS



ROAD GRADERS

BUSES AND TROLLEY COACHES

PASSENGER CARS

Exclusive steering specialists since 1906, Ross supplies the *right* gear for every steering need—*manual* or *power*.

Ross Cam & Lever manual steering has long been noted for maximum *ease* and *stability* in just the *right* combination . . . sturdy, rugged construction . . . minimum wear . . . simplicity and speed in any needed adjustment.

Active in power steering since 1942, Ross is currently producing—for a wide variety of vehicles—both *integral* and *linkage* types that are among the *simplest*, *surest*, most *economical* power units yet developed.

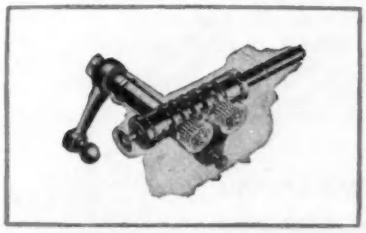
We invite discussion of *any* steering problem.

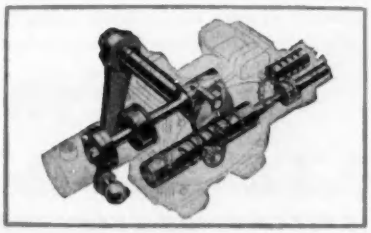
ROSS GEAR AND TOOL COMPANY • LAFAYETTE, INDIANA

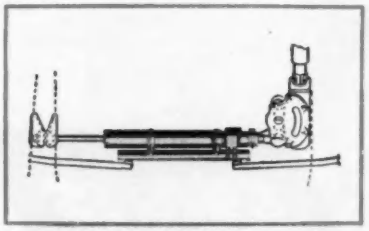
TRACTORS

EARTH MOVERS

A GEAR FOR EVERY NEED

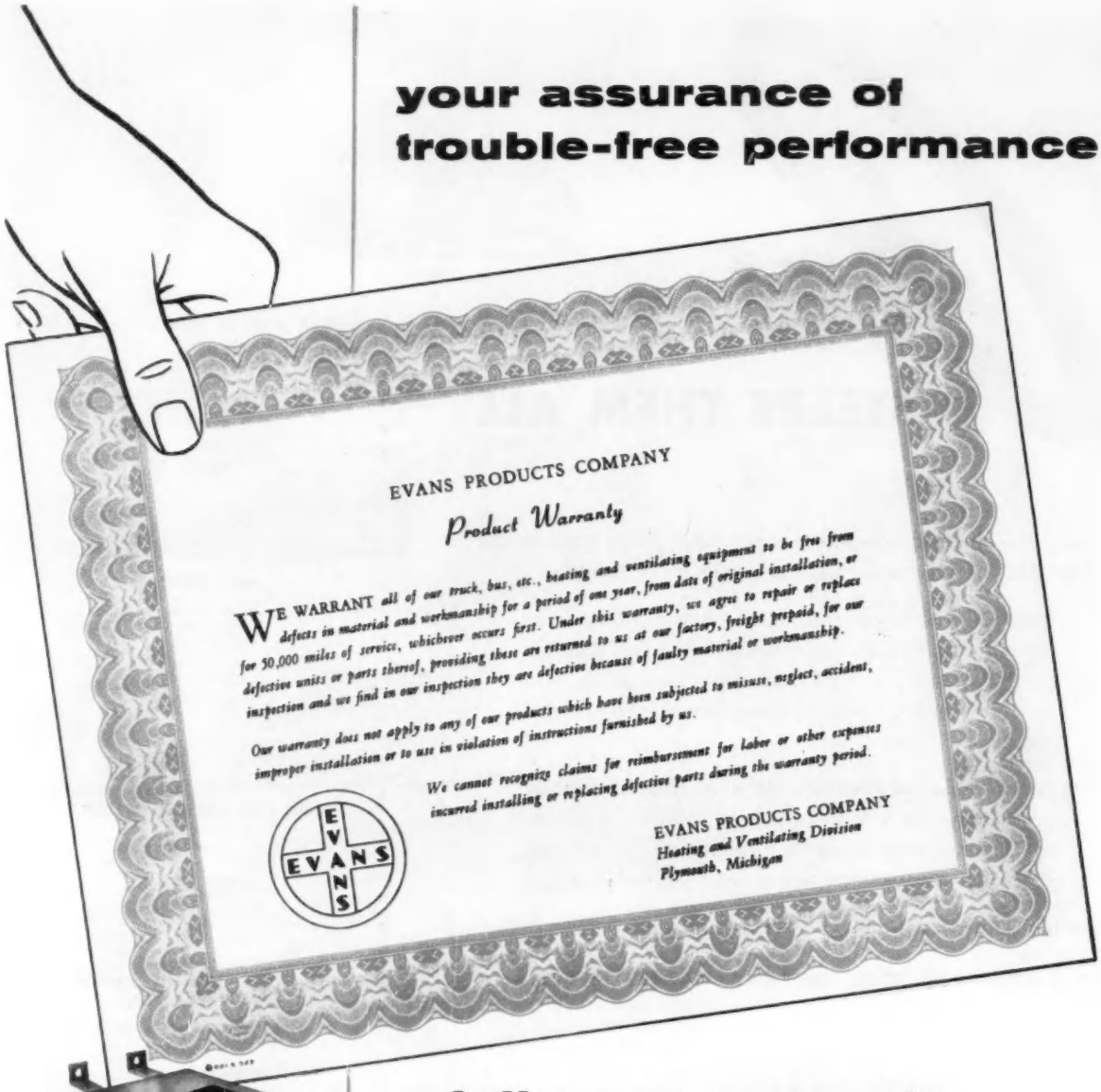






CAM & LEVER MANUAL . . . HYDRAPOWER INTEGRAL . . . HYDRAPOWER LINKAGE

your assurance of trouble-free performance


EVANS PRODUCTS COMPANY
Product Warranty
WE WARRANT all of our truck, bus, etc., heating and ventilating equipment to be free from defects in material and workmanship for a period of one year, from date of original installation, or for 50,000 miles of service, whichever occurs first. Under this warranty, we agree to repair or replace defective units or parts thereof, providing these are returned to us at our factory, freight prepaid, for our inspection and we find in our inspection they are defective because of faulty material or workmanship.
Our warranty does not apply to any of our products which have been subjected to misuse, neglect, accident, improper installation or to use in violation of instructions furnished by us.
We cannot recognize claims for reimbursement for labor or other expenses incurred installing or replacing defective parts during the warranty period.
EVANS PRODUCTS COMPANY
Heating and Ventilating Division
Plymouth, Michigan
EVANS
EVANS

a full-year warranty on every *EVANS* heater

Are you getting the protection of a full-year warranty* on the heaters you buy for your trucks or buses? You are if they're made by Evans. Evans heaters are custom-designed and constructed to meet the particular heating requirements of specific trucks and buses. Evans engineers are glad to work with you to develop a unit to your specifications, build prototypes quickly and conduct precision tests to latest A.S.H.V.E. procedures. For further information write Evans Products Company, Dept. Z-8, Plymouth, Michigan.

**or, 50,000 miles, whichever occurs first.*

Regional Representatives

Cleveland	Frank A. Chase
Chicago	R. A. Lennox Co., Inc.
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Allentown, Pa. .	P. R. Weidner

EVANS . . . **BALANCED HEATING & VENTILATING SYSTEMS FOR EVERY TRUCK AND BUS** . . . EVANS®

Are You Still Featuring

DAVENPORTS-ON-WHEELS?

No Need To!

Bringing the parlor to the open road was once the height of luxury. But in today's sleek new cars, sofa-like seats—for all their new springing and styling – are hangovers from the past. They're out of key with modern production economies, out of line with modern space requirements, out of step with modern tastes—*and completely unnecessary!*

Why? Because AIRFOAM is not "just another" cushioning material. It's a new way to design interiors! AIRFOAM creates production short cuts all its own, replaces costly and bulky springings, makes the smartest custom effects simple premolding operations!

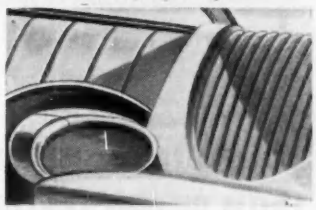
And what a space-saver AIRFOAM *can be!*

Design-wise, production-wise, you'll be way ahead—once you use AIRFOAM for what it is—a *new* material with *new* and unique advantages to be exploited in *new* and exciting ways!

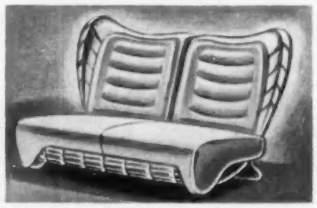
That is precisely what today's most successful *furniture* manufacturers are doing. Should the automotive industry be far behind?

AIRFOAM design engineers are right at your elbow. Write or phone Goodyear, Automotive Products Dept., Akron 16, Ohio.

AIRFOAM *saves precious space! More headroom—more footroom—without enlarging body!*



AIRFOAM *imparts custom looks at mass-production cost!*



AIRFOAM *makes exciting new seating ideas practical!*

AIRFOAM *can give you a sales-building lead on the field!*

More AIRFOAM in your line—means more names on the dotted line!

Airfoam MADE ONLY BY **GOODYEAR**

THE WORLD'S FINEST CUSHIONING

Airfoam—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

This KampLite Lantern throws new light on a familiar manufacturing problem . . .

NEW PART REQUIRED

Make it or Buy it?

The new KampLite is a real advancement in lantern design. The lamp is mounted below the tank, puts more light where you want it, eliminates shadows.

American Gas Machine Co., Division of Queen Stove Works of Albert Lea, Minnesota, recently faced a familiar problem in modern manufacturing . . . should they invest in the personnel, equipment, and time necessary to produce in their own plant the tanks for their newly designed KampLite . . . or would it be more economical and expedient to purchase the completed tanks from an outside source.

After consideration of all factors Burgess-Norton was selected for production of these tanks. Working together, American Gas Machine and Burgess-Norton engineers redesigned the tank for peak production efficiency and quality control, combining stampings and screw machined parts through hydrogen-copper brazing and projection welding.

Results for American Gas Machine Company:

Capital investment in new equipment was eliminated

Personnel and equipment procurement delays obviated

Additional floor space was not necessary

Manufacturing know-how contributed to a better tank

Costs were 15% less than American Gas had estimated for production of the tanks in their own plant

COMPLETE FACILITIES
FROM DESIGN THROUGH PRODUCTION FOR BETTER PARTS AT LOWER COSTS

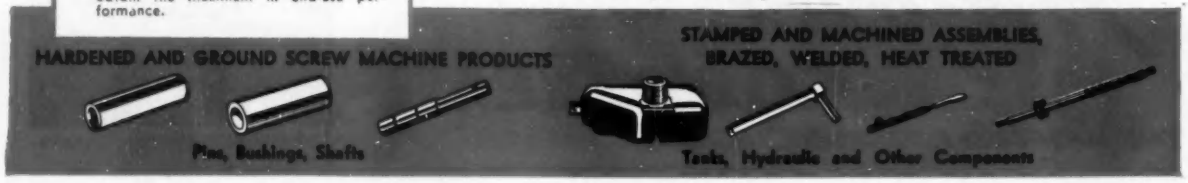
The high standard of quality required by industry today begins long before actual production. An experienced staff of engineers and metallurgists, working with the finest equipment, test, examine, and constantly check materials, heat treating and metal-working methods to obtain the maximum in end-use performance.

Burgess-Norton facilities and equipment are extremely diversified for the economical production of a wide range of precision parts, and include complete engineering, development, and metallurgy departments. This engineering service is available to you without obligation. If you have a parts production problem, we believe it will pay you to check into Burgess-Norton facilities. Send prints, specifications, or samples . . . or, if you prefer, one of our sales engineers will call, at your convenience.

BURGESS-NORTON MFG. CO.

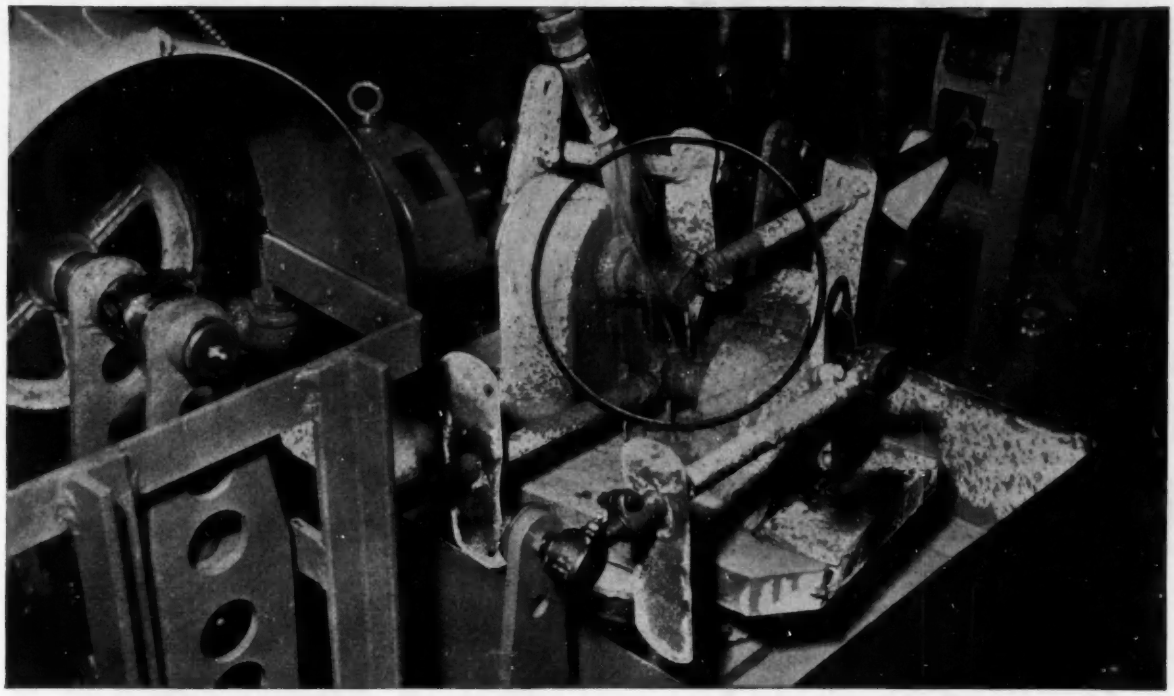
GENEVA, ILLINOIS

Serving Industry For Over 50 Years


HARDENED AND GROUND SCREW MACHINE PRODUCTS
Pins, Bushings, Shafts
STAMPED AND MACHINED ASSEMBLIES, BRAZED, WELDED, HEAT TREATED
Tanks, Hydraulic and Other Components

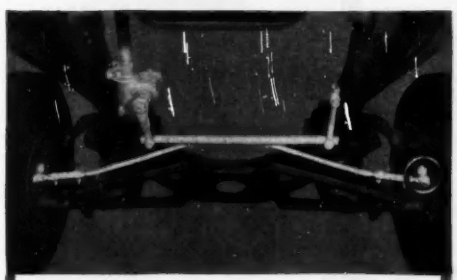
You can count on

Thompson's Performance-Tested steering linkage



A set of Thompson dual bearing tie rod ends gets the water treatment as part of a continuing test to determine the durability of this Thompson linkage.

This test, duplicating actual road conditions of the greatest extremes, is conducted for several weeks. Actually, in some tests, Thompson steering linkage units are subjected to the equivalent of more than 100,000 miles. Units are periodically removed from the testing equipment and carefully analyzed for wear.



You can count on

Thompson Products

MICHIGAN PLANT

Detroit • Fruitport • Portland

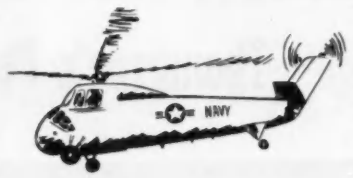
THOUSANDS of miles of all kinds of driving —mud, water, ruts, jars and jolts—that's the testing story behind Thompson's dual bearing tie rod ends. It's the story of Thompson Products' exacting steering engineers who carefully performance-test linkage in a laboratory especially designed to duplicate all road conditions. In addition, these linkage units are extensively road-tested by Thompson engineers.

Behind this story is the continuing search for improvement—in materials, in performance, and in manufacturing procedures. New materials, new manufacturing processes, new designs are all subjected to grueling performance tests, such as the one pictured here. Day and night this set of Thompson dual bearing tie rod ends will be subjected to mud, to water, to periods of dryness, and to periods when impact is applied.

The end result of exacting analysis of wear and tear and of thousands of miles of simulated driving, is the best possible linkage systems for cars, trucks, buses, and tractors. Another result is the successful development of such revolutionary steering aids as Thompson's ball-joint front suspension, the greatest advance in automotive steering in 20 years.

If you have a steering linkage problem, let Thompson's steering engineers help you. Just write or phone Thompson Products, Michigan Plant, 7881 Conant Avenue, Detroit 11, Michigan, WA 1-5010.

Why do most types of 'copters fly with Lycoming-built engines?



Lycoming-powered Sikorsky S-58 Anti-Submarine 'Copter*

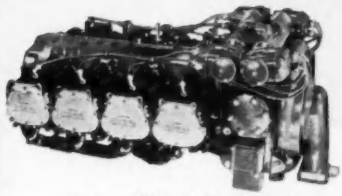
Lycoming-powered Piasecki H-21 Matériel and Troop Transport*

Lycoming-powered Kaman HTK-1 Military Trainer

Lycoming-powered Doman L-Z5 General Utility 'Copter

Lycoming-powered Brantly Model B-2 Personal 2-place 'Copter

Lycoming-powered Glenview FlyRide Personal 2-place 'Copter



4-, 6-, and 8-cylinder opposed air-cooled engines.

*7- and 9-cylinder radial air-cooled engines.**

LYCOMING TURBINE ENGINES

Still "under wraps," being developed for the Military. Lycoming's new "pioneers" that promise greater efficiency, greater economy, more brilliant performance than any helicopter engines ever before developed.

*Wright-Cyclone engine, built by Lycoming under license from Curtiss-Wright Corporation, Wright Aeronautical Division.

The answer is simple: Lycoming builds more types of power plants designed for varied types of helicopters than any other engine manufacturer. Some users are shown above.

Since 1940—when Lycoming powered the pioneering Vought-Sikorsky 300—Lycoming has produced engines ranging from 135 to 1500 horsepower. And they have been designed for horizontal, angular, and vertical mounting.

If your problem is air-cooled power . . . precision parts . . . volume fabrication . . . or "just an idea" in the rough or blueprint stage that needs development . . . *look to Lycoming*. Long famous for metal-working skills, Lycoming meets the toughest specifications of exacting customers, both industrial and military.

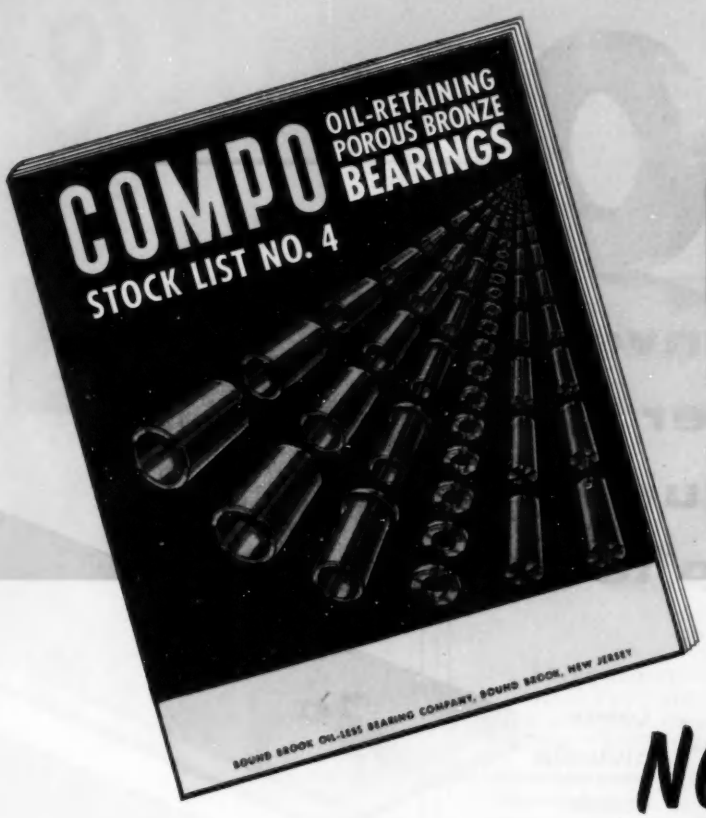
FOR RESEARCH • FOR PRECISION PRODUCTION

LOOK TO **Lycoming**

DIVISION OF AVCO MANUFACTURING CORPORATION

STRATFORD, CONN., Manufacturing plants in Stratford, Conn. and Williamsport, Pa.

AIR-COOLED ENGINES • PRECISION PARTS • TURBINE RESEARCH & DEVELOPMENT

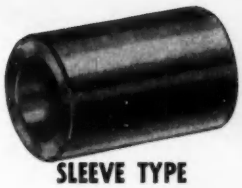


NEW COMPO

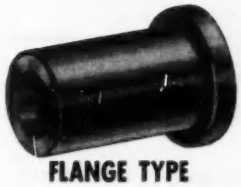
OIL-RETAINING POROUS BRONZE

BEARING

STOCK LIST NOW AVAILABLE



SLEEVE TYPE



FLANGE TYPE

BAR STOCK

CORED BAR STOCK

WASHERS

If you play a part in the design, production or maintenance of equipment using sintered bronze bearings, or if the job of purchasing bearings falls within your domain, you'll find a wealth of useful information within the 20 pages of the new Compo Oil-Retaining Porous Bronze Bearing Stock List No. 4. Bound Brook has compiled an easy-to-read list of the most popular stock sizes of bearings which are available for immediate shipment. In addition the Compo Stock List Brings you up-to-the-minute data on bearing application, installation, lubrication and machining. And here's another thought! When requesting your copy of the Compo Stock List why not have us send one to your supplier of bearing-using components or equipment? It may enable him to make savings beneficial to you both.

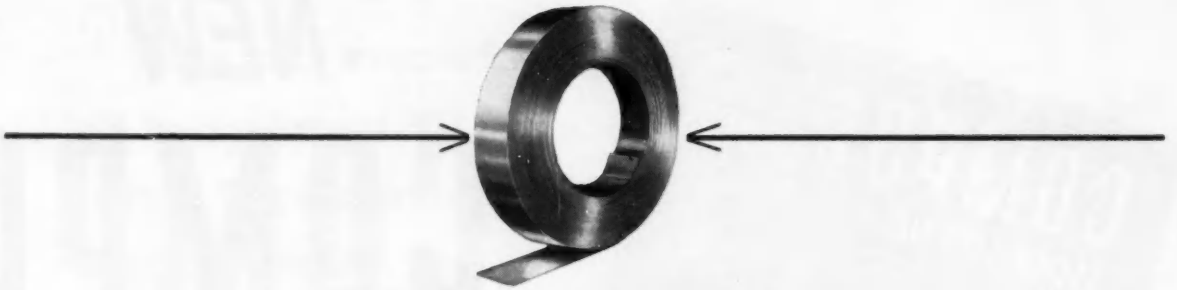
Write for a list of location of local warehouse stocks. 4

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS & PARTS



Conversion from Copper to ALCUPLATE® can Reduce Your Cost up to 30%

What is ALCUPLATE?

ALCUPLATE is a solid layer of copper permanently clad on one side or both sides of less expensive aluminum.

This gives you solid copper performance at a lower cost over solid copper.

In addition to its lower cost, ALCUPLATE has virtually the same physical and electrical properties as pure copper. This permits fabrication of many parts and products from ALCUPLATE at savings of from 15%–30% over solid copper.

Can ALCUPLATE be worked?

ALCUPLATE can be fabricated by stamping, drawing, spinning and forming. The copper provides an ideal surface for soft-soldering operations and electroplated or other finishes.

In what sizes is ALCUPLATE stock available?

In coils or flat stock up to 1/16″ thick x 13″ wide and in a choice of thickness ratios and tempers.

ALCUPLATE FEATURES:

- Natural copper appearance
- High electrical conductivity
- Excellent heat dissipation
- Soft-soldering surfaces
- Easy fabrication
- Light weight

ALCUPLATE®

For further information, write or wire

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
118 FOREST STREET, ATTLEBORO, MASS.

For the Sake of Argument

More About Leaders . . .

By Norman G. Shidle

A leader must not be too far ahead of those he aims to lead . . . nor too far behind. He must be ahead of the pack. But the pack must readily sense the relation of its problems to the leader's ideas.

As a leader runs too far ahead, his tie-line of leadership ravels thinner and thinner. Then one day, he may look back to find it broken. If he looks back too late, he may see his group disappearing over an opposite horizon.

He can be even worse off if he falls behind. Then his tie-line reels out fast. He's like a fisherman with a light rod who has hooked a big game fish. If he holds a close connection by force, the line may break. If the reel slips from his fingers, he's left far behind. He's lost control as well as leadership.

The real tragedy when a leader falls behind is to the organization rather than to the leader. Every group needs leadership.

Back in the middle '40s we wrote (under "Little Men, Little Thoughts"): "We know plenty of fiftyish executives who belittle aggressive action by younger subordinates . . . exerting the leadership of an elephant sitting on a can full of wasps." And, never will a can full of wasps go places and do things like a swarm of bees in the wake of their queen.

"No plan will work at all" says Lyndall F. Urwick, "unless it is inspired and led by the individual holding the highest executive responsibility in the area to which it is applied."

Continuing in his penetrating "Management Education in American Business" he adds in effect:

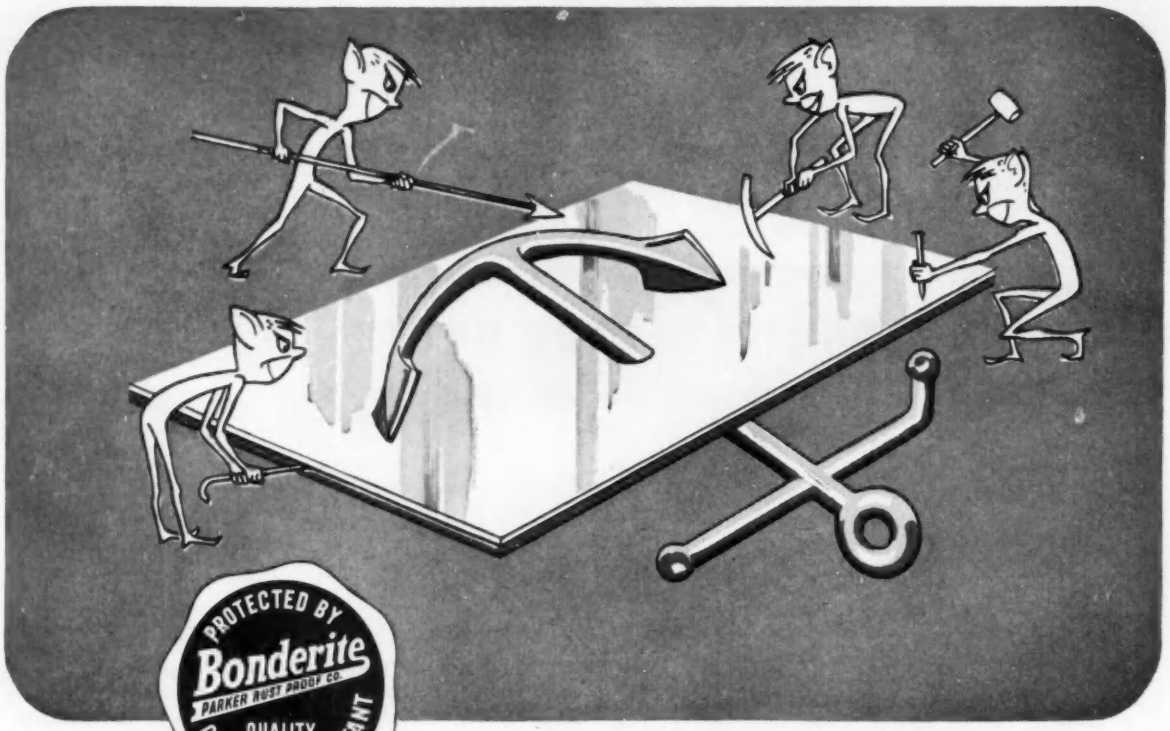
In any undertaking, the chief executive must be prepared:

a. To give the time and energy to spark a program, to get it going and to give it constant inspiration and encouragement;

b. To carry it out in detail himself with all those immediately responsible to him—and to see that they carry it out with their immediate subordinates.

In terms of leadership, Urwick's conclusions add up to something like this:

Consistent participation is the only tie-line with those led which permits a leader to lead.



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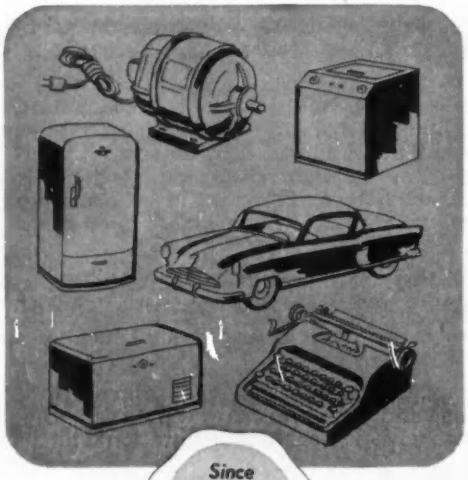

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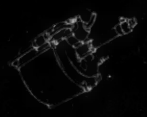

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Drafting Practice on Threshold of More Realistic Tolerancing

Proposal of SAE Joint Aeronautical and Automotive Drafting Committee promotes greater interchangeability by relating geometric and positional tolerances to size tolerances.

P. G. Belitsos, General Electric Co.

Progress report on the work of the SAE Joint Aeronautical and Automotive Drafting Committee.

IT has been said by many authorities that the standardization of engineering drawing practice in America, Britain, and Canada is probably the most important single step that these three democracies could take to make better use of their combined resources.

This would make possible a common language for the expression of engineering requirements which would reduce the loss of valuable time and money required to translate the drawings made in one country into the practices used by another. To accomplish this standardization is a gigantic undertaking. But it is well underway and should be successfully completed based on the precedent established by the adoption of the Unified Screw Thread Standard by these same ABC countries.

Joint SAE Committee

In September, 1952 the American Standards Association, in a meeting of its Sectional Committee Y14 on Drawings and Drafting Room Practice, asked various industries to study a proposed British Standard (BS308) on Engineering Drawing Practice.

Each of these groups, including the aeronautical and automotive industries, carefully reviewed this Standard in separate meetings to determine their respective positions regarding the practices established by the British Standards Institution. It was agreed by all that, in general, the basic principles were consistent with American practice but that the British introduced some new concepts, particularly in the field of positional and geometric tolerancing

SERVING on the SAE Joint Aeronautical and Automotive Drafting Committee are:

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which had much merit and required further intensive study and comparison with American Practices.

(Positional Tolerance is the permissible variation in the specified location of features of a part from each other and/or from a common datum. Geometric tolerance is the permissible variation in specified form of the individual features of a part.)

The drafting representatives of the SAE aeronautical and automotive groups subsequently decided that much could be accomplished in the way of establishing a basis for American drafting practice if they could agree on a common drafting standard on dimensioning and tolerancing, with particular emphasis on geometric and positional tolerancing. Accordingly, a joint SAE Drafting Committee was formed to accomplish this.

The initiation of this activity was timely because of the experience gained by many companies in the multiple source programs inaugurated by the Government after the start of the Korean war. In building products such as aircraft gas turbine engines by many automotive companies, it became evident that there were many differences in automotive and aeronautical drafting practices which could be reconciled without much difficulty.

Each company involved in this study appreciated the urgent need to arrive at a common understanding for defining engineering requirements on drawings. From experience during the war with expanded subcontract operations, it also became apparent that drawings prepared for use in workshops of widely varying equipment and experience required more complete and explicit dimensioning and tolerancing expressed in terms that required no interpretation.

Basic Principles for Tolerancing

After considerable study, it became apparent that the foundation of the British system of geometric and positional tolerancing could be reduced to three

The Three Principles of the

PRINCIPLE 1: When the geometric or positional tolerance note includes the designation MMC, it indicates that the stated tolerance applies only at the maximum metal condition of the part.

For example, Fig. 1 illustrates a pin whose actual size may vary from 0.990 to 1.000 diameter. It also includes a note which specifies a geometric tolerance of straightness of 0.005. Such a note would mean that if the size of the features are at their maximum metal size, the geometric or positional tolerance cannot vary beyond the value specified. However, if the size of the features are less than maximum metal size, an increase of geometric or positional tolerance is available and permissible.

In the worst condition, this pin will just be able to enter a truly cylindrical hole of 1.005 diameter, as shown in Fig. 2. However, if the pin is finished to a size other than its maximum metal limit, as for example 0.990, there will be an increase in the assembly clearance. In this case a larger straightness tolerance than that stated on the drawing could be allowed as shown in Fig. 3 without endangering free assembly. This increase of geometrical tolerance is equal to the difference between the specified maximum metal limit of size and the actual finished size of the feature.

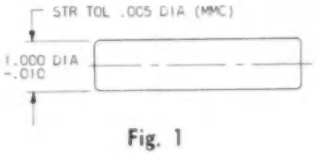


Fig. 1

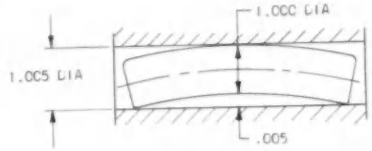


Fig. 2

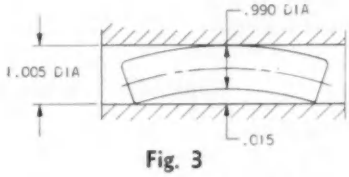


Fig. 3

PRINCIPLE 2: When the geometric or positional tolerance specified on the drawing is to be machined within the expressed limit, regardless of the actual finished sizes of the features concerned, the designation MMC is omitted.

The tolerance note is expressed as shown in Fig. 4. This note means that the surface or the axis of the feature must in all cases be within a tolerance zone whose diameter is the value specified. See Fig. 5 for interpretation.

basic principles. Before stating these principles it will be well to briefly sketch a background of the requirements for dimensioning for interchangeability.

When two mating parts are to assemble on an interchangeable basis it is necessary to dimension the fits to suit the functional requirements of the design and at the same time permit universal exchange of parts without the necessity of fitting at assembly. In manufacturing parts for interchangeable use, it is recognized that there will be variations in the actual size of each part within the specified limits; and due to the inaccuracies of the machinery and equipment, there will also be errors in the form or position of the features of each part.

The least favorable condition for the assembly of mating parts occurs when the mating features such as holes, pilot diameters, slots, and so forth, are at their maximum metal condition of size, and the maximum variations permitted by geometric or positional tolerancing are present. (Maximum metal condition (MMC) is that limit at which a part contains the maximum amount of material. This would be the maximum external limit and the minimum internal limit.)

In establishing the following three basic principles, the British recognized the need for specifying directly on the drawing the relationship between the geometric or positional tolerance and the size tolerance. These three principles are discussed below.

True Position System of Dimensioning

To determine the SAE position on these principles, it was decided to take some typical SAE drafting practice which embodied all the basic elements involved in this study, analyze the existing practice and modify it to incorporate the latest advances in tolerancing methods used in this country and abroad. The true position system of dimensioning

British System of Tolerancing

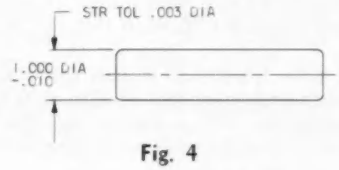


Fig. 4

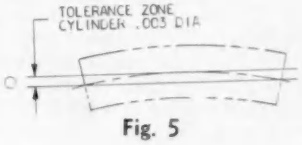


Fig. 5

PRINCIPLE 3: When it is necessary to contain the specified geometric or positional tolerance within the maximum metal limits of the features, the tolerance note should state a requirement of ZERO (MMC). See Fig. 6.

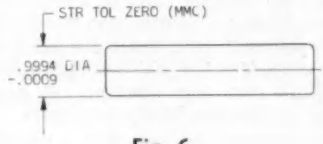


Fig. 6

Such a note would mean that if the features are finished everywhere on their maximum metal limits of size they must be perfect in form (truly straight, square, concentric, and so forth). However, errors of form are permissible if the features are away from their maximum metal limits of size in the direction of minimum metal.

The use of a 'ZERO' tolerance in Principle 3 met with strong objection from all segments of industry, mainly because it was foreign to American practice and because of its adverse psychological reaction on manufacturing people. Also, the fundamental concept established by this principle has been recognized in U. S. industry by the common interpretation of size limits. If there are no specific form tolerance requirements specified on the drawing, the part is acceptable if it is within the size limits.

These size limits define a tolerance zone or boundary which restricts not only the size but also the allowable variations in geometric form. In such cases if a part is to maximum metal size, it follows that it must have no variations from true form (equivalent to ZERO MMC) to pass conventional inspection methods. On this basis, therefore, it was decided that consideration would be given only to the detailed study of the application of the first two principles.

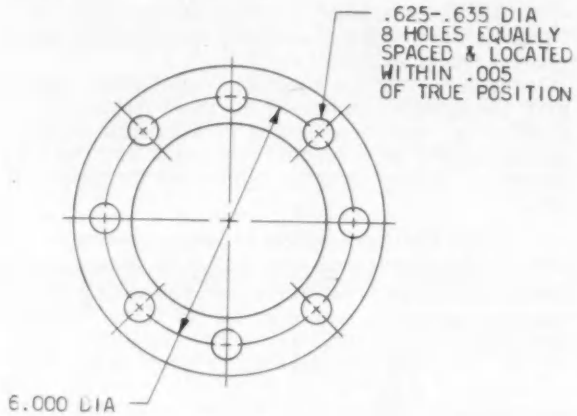


Fig. 7—In this case, the true postion of each hole is determined from the basic bolt hole diameter and the basic angular relationship established by the drawing note

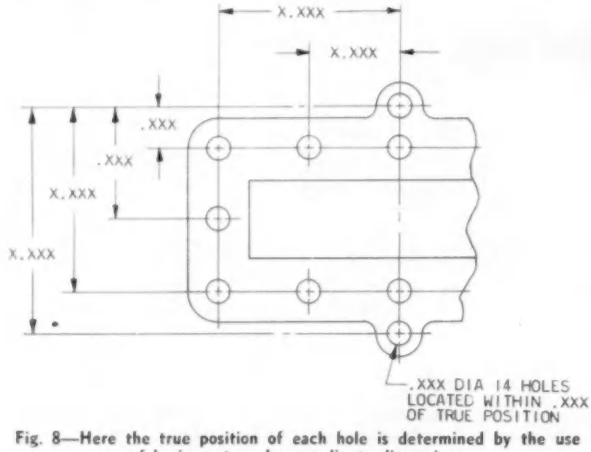


Fig. 8—Here the true position of each hole is determined by the use of basic rectangular coordinate dimensions

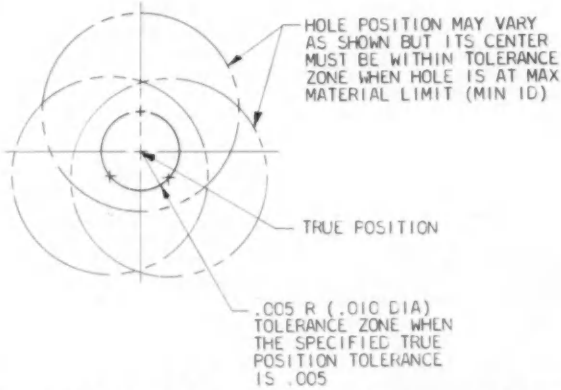


Fig. 9—The cylindrical tolerance zone shown here defines the area of permissible variation for hole center location as well as variation in squareness of hole axis

groups of cylindrical features was selected because it incorporated the most advanced techniques for the dimensioning of mating parts which have to assemble on an interchangeable basis. It was also particularly suitable since it was recognized: (1) by the British Standards Institution in BS308, (2) by the Canadian Standards Association in CSA B70.1, (3) by the U. S. Office of Standardization in MIL-STD-8A, and (4) by the American Standards Association in its proposed Y14-5 Standard on Dimensioning.

In this system, the theoretically true location of each cylindrical feature such as a hole is defined by the use of basic[1] (untoleranced) dimensions expressed in any suitable form of dimensioning, whether it be angular, rectangular, and so forth. On drawings which use a block of general tolerances, the word 'BASIC' may be applied to each locating dimension as applicable; or this general note may be used: 'DIMENSIONS LOCATING TRUE POSITION ARE BASIC.' This establishes the theoretically exact position for each hole. Then in the drawing note which specifies the number and size of holes, the phrase 'WITHIN .XXX OF TRUE POSITION' is used. See Figs. 7 & 8.

In terms of the axis of the hole, this means that the axis at all sections along its length must fall within a cylindrical tolerance zone whose radius is equal to the true position tolerance and whose center is located at True Position as shown in Fig. 9. This tolerance zone also defines the limits within which variations in the squareness of the axis of the hole must be confined with respect to the surface.

Since the hole itself has a size tolerance which provides a high and low limit of size, it is necessary for the designer to define clearly on the drawing the condition of size to which the positional tolerance is applicable.

For many years in the aeronautical industry, where this method was widely used, there was an understanding established in workshops and inspection departments that the specified tolerance applied only to the maximum metal condition. This was based on the previously stated fact that the least favorable condition of assembly occurs when the mating features are at their maximum metal condition of size and the maximum variations permitted by the positional tolerance are present.

If this condition of assembly is controlled, it follows that the additional tolerance available as the mating parts approach minimum metal size will result in parts with the largest acceptable assembly clearances. This fact was covered on engineering drawings only by implication, and over the years the proper interpretation has been passed on by word of mouth.

This was satisfactory only when it was possible to contact the design engineering department when there were any misunderstandings or misinterpretations of this or other similar engineering requirements. However, with the increased use of sub-

[1] A dimension specified as BASIC is a theoretical value used to describe the exact size, shape or location of a feature. It is used as a basis from which permissible variations may be assigned.

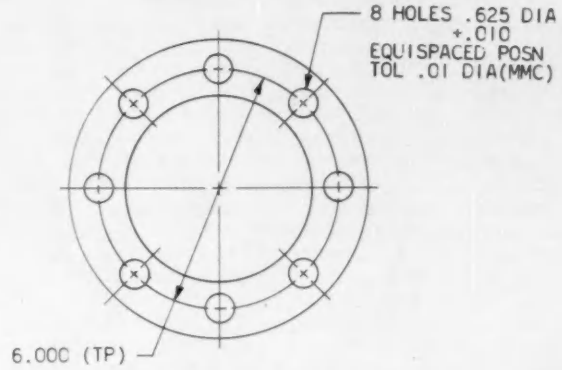


Fig. 10—This illustrates the British method of specifying that the positional tolerance applies to the (MMC) maximum metal condition of size

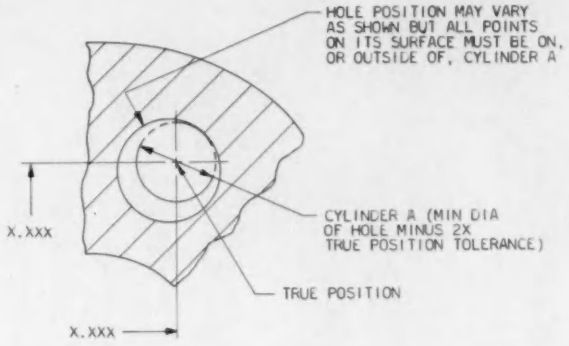


Fig. 11—This is a realistic interpretation of true position dimensioning

contract operations, this reliance on workshop 'know-how' became impractical and expensive. The British recognized this fact and covered this condition as outlined in Principle 1 by specifically stating it as part of drawing note with the use of the abbreviation for maximum metal condition, MMC. See Fig. 10.

Since this condition has been hitherto only implied in American practice, the joint SAE committee decided to specifically establish this condition by the use of the following general note on the drawing when required:

'TRUE POSITION TOLERANCES SPECIFIED ARE FOR MAXIMUM MATERIAL CONDITION ONLY UNLESS OTHERWISE SPECIFIED'.

From this it followed that where the actual size of the holes were other than at the maximum material condition, the design permitted an additional positional tolerance.

Since interchangeable manufacture concerns itself primarily with surfaces rather than imaginary centers or axes, a realistic interpreation of the application of true position dimensioning was developed. This states that in terms of the cylindrical surface of a feature, such as a hole, it means that all points on this surface shall be on, or outside of a cylinder having a diameter equal to the minimum diameter of the hole minus twice the true position tolerance, with the center of the circle located at True Position. See Fig. 11.

Use of Position Gages

The important advantage in the use of the true position method is that it establishes a circular tolerance zone in contrast to the corresponding square tolerance zone provided by directly toleranced center distances. This circular tolerance zone permits full tolerance deviation in all directions. However, the square tolerance zone permits full tolerance only diagonally thru the corners of the square forming the zone. The circular tolerance zone also facilitates inspection because it corresponds to the control exercised by position gages.

In terms of gaging, the phrase 'WITHIN .XXX OF TRUE POSITION' means that the holes in a part, such as shown in Fig. 7, are within the true position tolerance specified, if they receive the corresponding pins of a gage made to the requirements shown in Fig. 12. The inspection for the size of the holes is made independent of the inspection for position of the holes. It is interesting to note that for many years many of the automotive companies have been defining requirements for groups of holes in mating parts by specifying in note form that the holes must freely admit a gage with .XXX diameter pins located on true position. The size of the gage pins was determined to produce the end result required.

However, this method was eliminated since it was decided that SAE practice would be established on the basis of specifying only the desired end requirements for the engineering design. That allows maximum flexibility as to the method or process to be used by manufacturing and inspection in meeting these requirements.

Control of Position at any Condition of Size

The functional requirements of some designs demand that certain features be held to a uniform

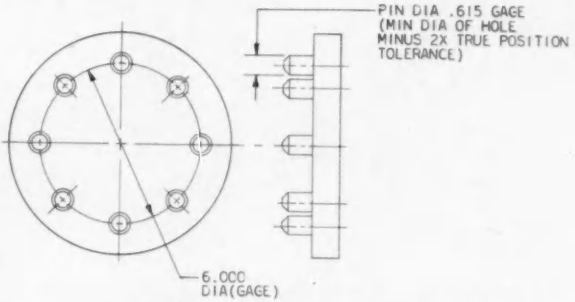


Fig. 12—Gage designed to check the holes of the part in Fig. 7 to see if they are within true position tolerance

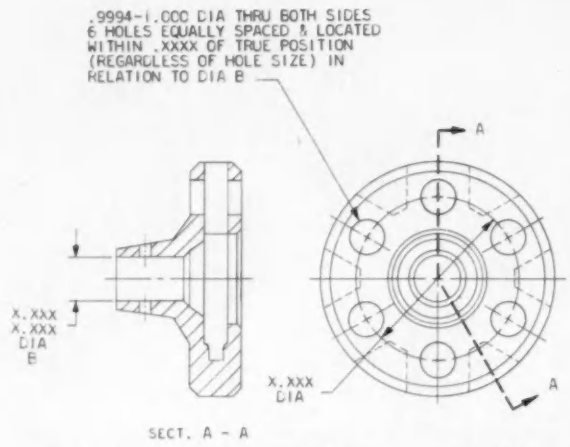


Fig. 13—In the case of this planetary pinion cage, each hole location has to be held within the specified positional tolerance, regardless of hole size

positional tolerance, regardless of whether the features are at the maximum metal limit or not. For instance, in the planetary pinion cage shown in Fig. 13, the six shaft holes may vary in size from 0.9994 diameter to 1.0000 diameter. Thus, it would be possible that in a given cage, the six individual hole diameters might measure; 0.9994, 0.9995, 0.9996, 0.9997, 0.9998 and 1.0000. However, to minimize the spacing errors of the pinions in the cage, each hole location should be maintained strictly within the specified positional tolerance, regardless of the size of the hole. That is, a hole at maximum material condition (0.9994 diameter) should be just as accurately located as a hole at minimum material condition (1.0000 diameter).

When this restricted positional control is required, the proposed SAE Standard states that the phrase 'REGARDLESS OF HOLE SIZE' shall be added to the true position note. This requires that inspection must be based on a method which will locate the actual center of each hole. It is evident that this type of control will be used in limited applications and requires more complicated and expensive positional gaging.

As was noted earlier, the British also recognized this type of situation and devised the method outlined in Principle 2 to cover designs whose requirements dictated this type of control. However, in this case, the fact that the positional tolerance must be maintained regardless of the size of each applicable feature is specifically stated on the drawing per the proposed SAE Standard. It is only implied by interpretation in the British Standard.

Application to Non-Cylindrical Features

In addition to the application of true position dimensioning to groups of cylindrical features such as holes, bosses, and so forth, this study revealed that the basic principles are equally applicable to groups of non-cylindrical features such as slots,

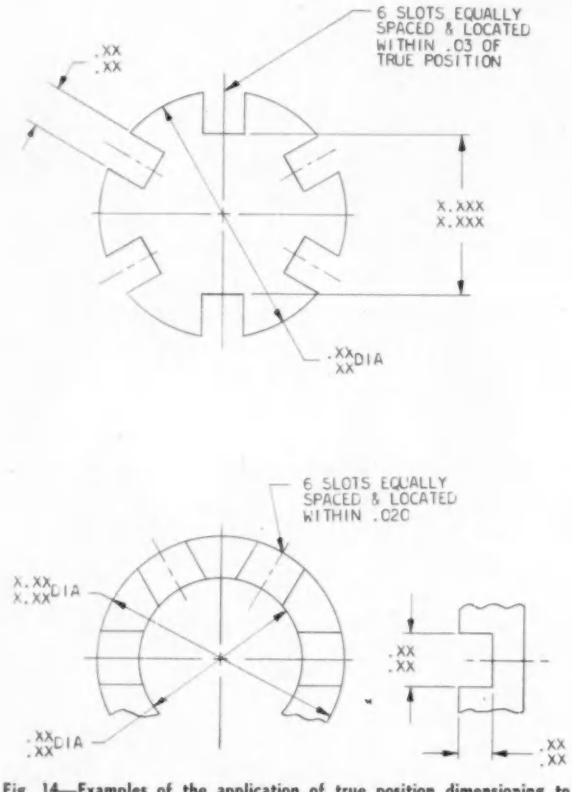


Fig. 14—Examples of the application of true position dimensioning to non-cylindrical features

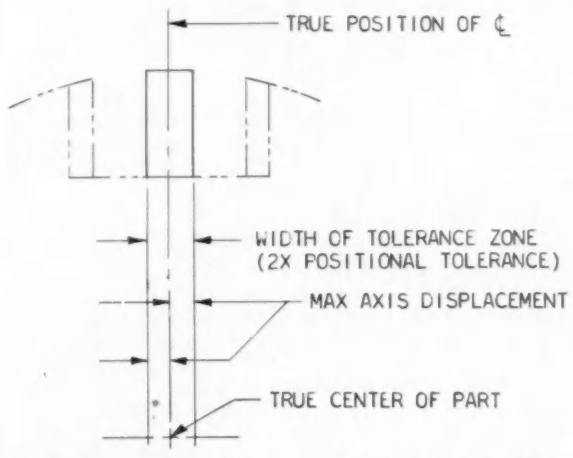


Fig. 15—The rectangular tolerance zone for the true position of the centerline of the slot is twice the true tolerance position

tabs, dovetails, serrations, and so forth. A few of the companies had already had successful experience in limited applications of this type. See Fig. 14.

The differences are mainly in the geometry of the tolerance zone. For example, in terms of the axis of the slot the note 'LOCATED WITHIN .XXX OF TRUE POSITION' means that the axis of the slot which is at maximum material condition (slot with minimum width) must fall within a rectangular tolerance zone which is symmetrically disposed with respect to the true geometrical position of the axis by the amount of the True Position tolerance. The total width of the tolerance zone is twice the True Position tolerance. See Fig. 15.

Since interchangeable manufacture in this case also concerns itself primarily with surfaces rather than with imaginary centers of axes, a realistic interpretation of the application of true position dimensioning to non-cylindrical features was developed. This states that in terms of the positioning surfaces of the slot, it means that all points of these surfaces shall be on or outside of a positional zone whose sides are parallel to the true position centerline and are spaced apart an amount equal to the minimum width of the slot minus twice the True Position Tolerance. See Fig. 16.

Again the shape of the tolerance zone established by this method of tolerancing facilitates inspection by means of simple positional gages. In terms of gaging, the phrase 'WITHIN .XXX OF TRUE POSITION' means that the slots in a part such as shown in Fig. 14 are within the true position tolerance specified if they are received by a gage made to the dimensions shown in Fig. 17.

True Position in Relation to Datum Surfaces

There are many designs for interchangeable assemblies that require parts which have groups of cylindrical or non-cylindrical features that must be located in relation to an integral datum such as a pilot. See Fig. 18. In these cases, the true position tolerance applies to the hole-to-hole relationship and also to the pilot-to-hole relationship. However, the true position tolerance specified must be maintained to the values specified only if both the pilot and the hole are at maximum material condition. Any hole not at its maximum material limit is permitted an increase of positional tolerance to the extent previously described. Furthermore, if the pilot is not at its maximum material condition, a further increase of positional tolerance is permissible for all the holes in relation to the pilot, but not in relation to each other.

The important work that this Joint SAE Aeronautical and Automotive Drafting Committee has completed to date is gaining wide recognition in their respective industries. The American Standards Association has also recognized this work to the extent that it is being considered for use as the basis for the dimensioning section of its forthcoming national drafting standard. Any progress in the establishment of widely accepted practices for preparing drawings is of great importance not only to engineers, but to all users of drawings. It will help to eliminate the constant misunderstandings which plague engineering, manufacturing, and inspection personnel with respect to what is intended and required by the various call-outs on drawings.

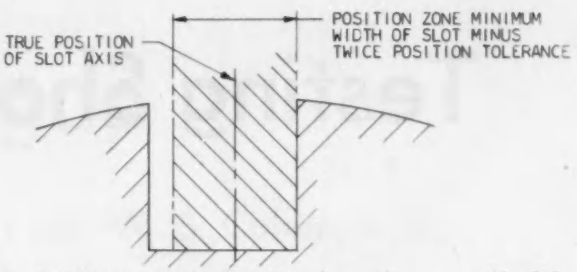


Fig. 16—All points on the slot surfaces have to be on or outside of the positional zone

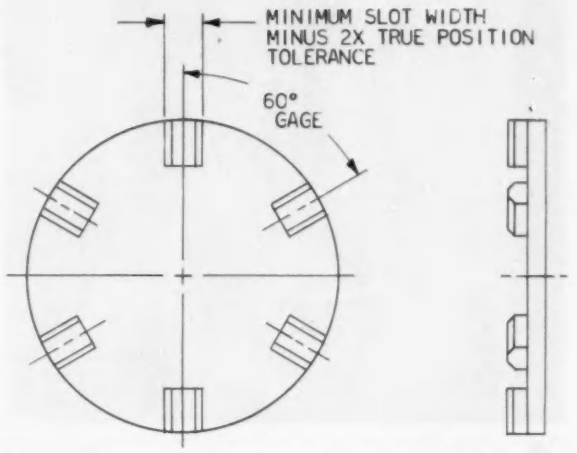


Fig. 17—The Slots of the part in Fig. 14 are within the true position tolerance specified if they are received by a gage shown here

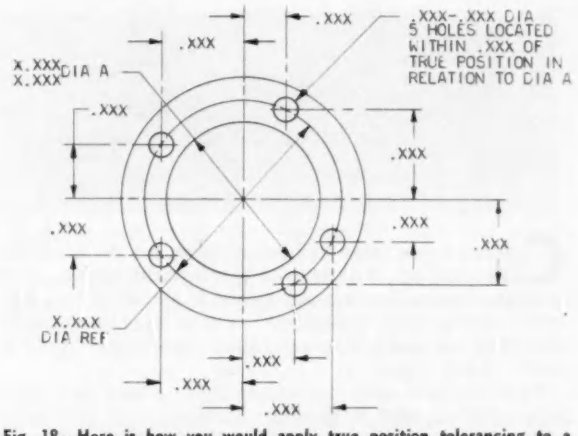
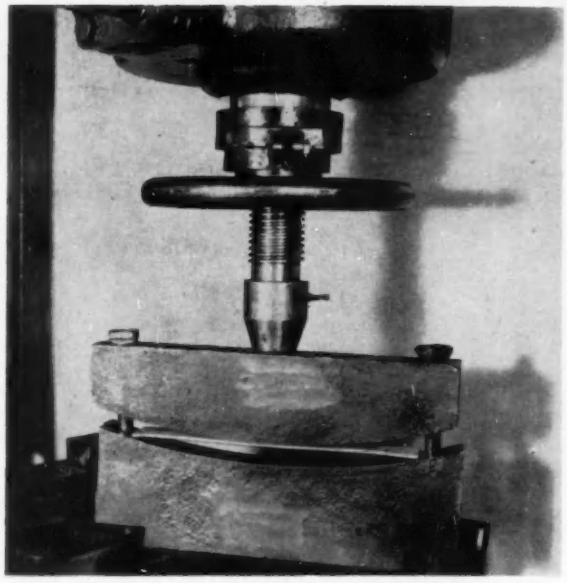
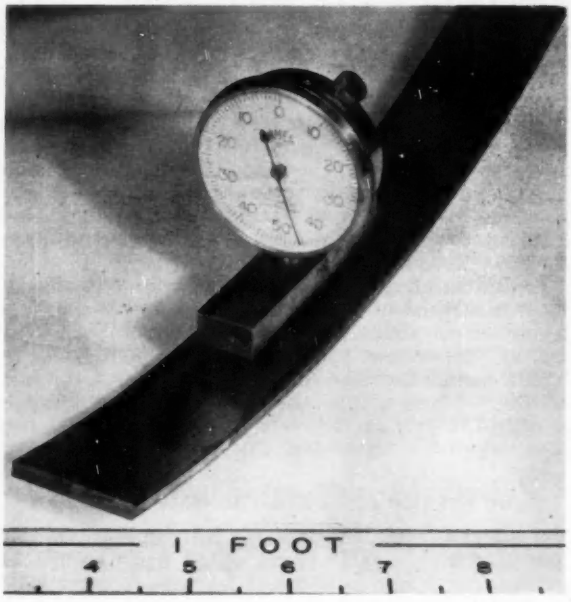


Fig. 18—Here is how you would apply true position tolerancing to a part with features that must be located in relation to an integral datum such as a pilot

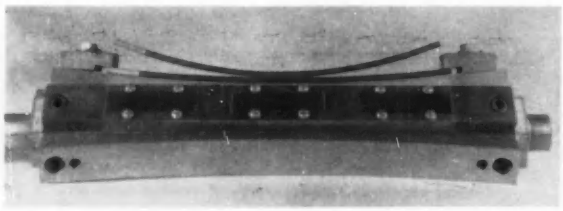
Testing Shot Peened Leaf



A Specimens were machined from hot-rolled SAE 5147 and ground to 0.192 × 1½ × 12 in., with a 1/16-in. radius on lengthwise edges. After 25 minutes at 1600 F in 2–4% excess oxygen, specimens were preset in this fixture.



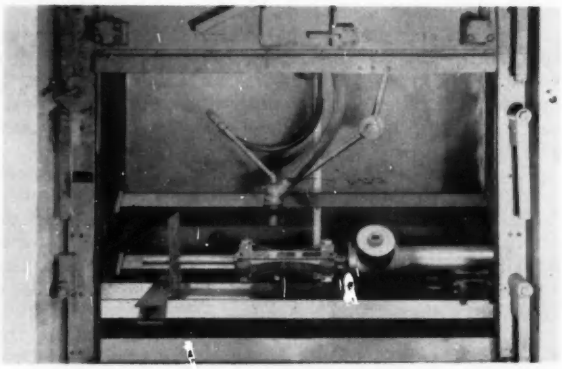
B Each specimen was held between curved blocks for 30 sec under 5000-lb load, then quenched in the fixture in oil at 110–120 F. Next specimen was removed and tempered to Rc 48. Gage checks curvature.



C Presetting stresses specimens to a nominal 220,000 psi, which is 10% over test stress. For peening under tension, specimen is clamped to a fixture having less curvature. (Note specimen with identical curvature as clamped specimen in free position on top.)

This fixture will accomodate five springs plus three Almen test strips for exposure and intensity data. Other fixtures provide other degrees of surface tension for strain peening.

Fixture rotates and reciprocates beneath the air nozzle of the shot peening equipment.

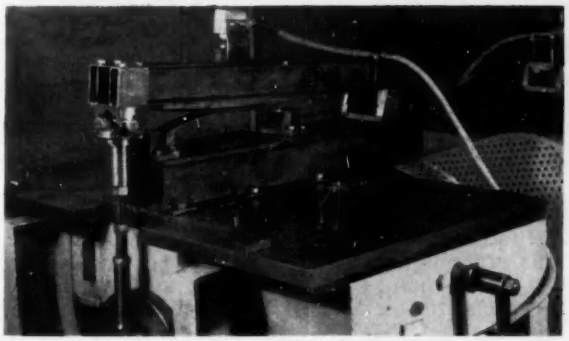


D This experimental air peening machine designed in our laboratories processed the specimens. Shot was commercial chilled iron shot screened accurately to size. An orifice controls shot flow rate.

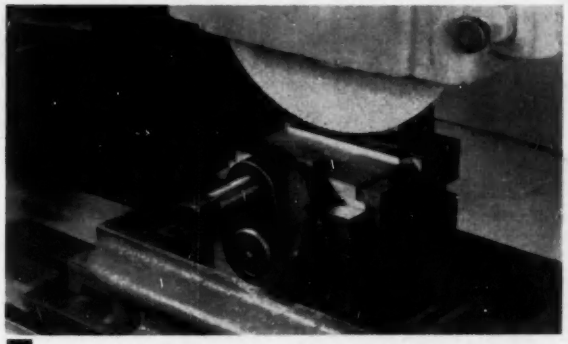
Springs In Fatigue

R. L. Mattson and W. S. Coleman, Jr.,
Research Laboratories Division, GMC

Based on paper "Effect of Shot Peening Variables and Residual Stresses on the Fatigue Life of Leaf Spring Specimens" presented at meeting of Division XX—Shot Peening of the SAE Iron and Steel Technical Committee, Hershey, Pa., Oct. 1, 1953.

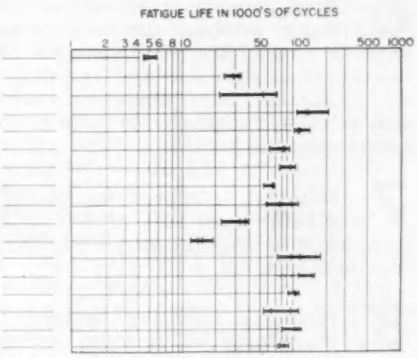


E Stroking machine was adjusted so that at maximum deflection, the curved "shoe" contacted the center 6 in. of the specimen. Shoe curvature was selected to stress specimen surface to 200,000 psi.



F Layers 0.001 in. thick were ground off pieces cut from fatigue specimens. Stress at the ground surface was determined each time a layer was removed from measurements of the curvature of the piece after its release from the grinder vise.

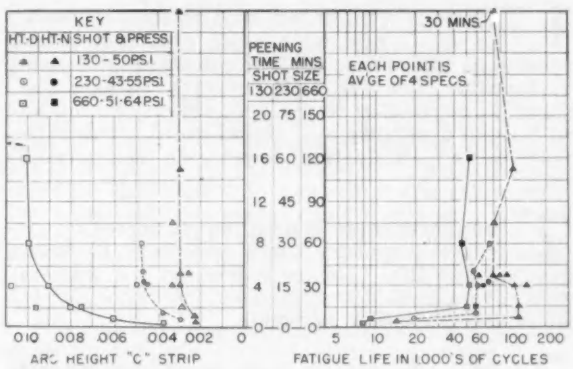
BATCH NO.	SHOT SIZE	AIR PRESS PSI	TIME EXP MIN.
28D	NO PEENING		
37D	SAND	80	1
31D	SAND	80	4
70D	*130	50	4
68D	130	50	4
44D	130	50	5
113N	130	50	5
93N	130	50	5
55D	130	75	5
54D	130	25	5
43D	130	50	0.5
41D	130	50	1
39D	130	50	2
33D	130	50	5
53D	130	50	10
40D	130	50	15
42D	130	50	30



*CORRESPONDS TO OLD S.A.E. #13

G Test results showed sand blasting improved fatigue durability by about four times over non-peened specimens. No. 130 shot (about 0.013 in. in diameter) improved fatigue life still more. Duplicate tests on specimens of different heats showed that results are reasonably consistent.

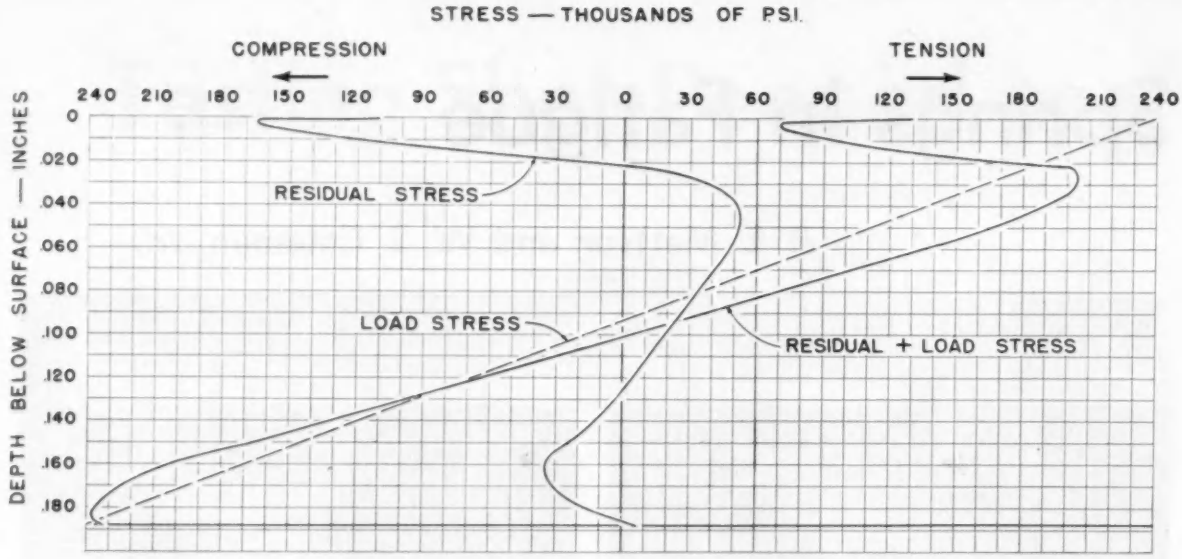
Data on Batches 55D and 54D plus other data suggest that for each shot size there is a minimum air pressure to obtain maximum fatigue durability and that beyond this value of air pressure, no further gain results. This value of air pressure is less for the larger sizes of shot.



H Fatigue durability evidently increases up to a point with exposure time as measured by the Almen strip. Further exposure is of no particular benefit, these results on shot of three sizes seem to indicate.

(The Almen strip was peened along with the fatigue specimen. The more completely it is peened, the more the strip tends to curve. Therefore, its "arc height" is a measure of coverage, and indirectly of exposure time.)

Effects of shot velocity and intensity and of strain state and post-peening temperature of the work piece were also studied. **Please turn page**



When bending stresses are added to the residual stress due to shot peening, the resultant stresses in the surface layers are considerably reduced.

That is, in fatigue loading these peened, compressively stressed surface layers experience a much lower peak stress than they would without shot peening. Since cracks and roughness at the surface are stress raisers, the reduction in resultant stress at the surface is particularly important.

When the resultant stress is plotted against fatigue life, the data take the shape of the familiar S-N (strength versus number of stress cycles) curve. This explains why fatigue life varied from 5000 cycles for the non-peened specimens to nearly a million cycles for certain strain-peened specimens, despite the fact that the test stress for all specimens was 200,000 psi.

Conclusions

1. There is a minimum shot velocity necessary to obtain best fatigue life with shot peened specimens like these. This minimum shot velocity varies with shot size. Air pressures greater than those corresponding to this shot velocity do not add to fatigue durability and are wasteful. This minimum value is considerably lower than that normally used.

2. Similarly there is a minimum degree of coverage (exposure time) necessary to obtain best fatigue life. Longer exposures are wasteful. Full coverage as determined by the "knee" of the Almen strip curve is adequate.

3. Shot size doesn't make much difference to fatigue life of specimens like these.

4. Shot peening increased fatigue life 20 times at 200,000 psi stress (approximately 95% of yield strength).

5. Shot peening specimens under tensile strain (Patent No. 2,608,752) increased fatigue life at 200,000 psi stress to 10 times that of specimens peened strain free, and to 200 times that of non-peened specimens. Greatest benefits are derived from shot peening while under stress greater than 80% of the yield strength.

6. Shot peening specimens of this type introduces residual compressive stresses of the order of 50% of the yield strength of the material, regardless of shot size and velocity. The depth of the compressed layer increases with both shot size and velocity, ranging from 0.006 to 0.026 in. for the treatments used.

7. Residual compressive stress considerably greater than 50% of the yield point can be introduced by shot peening while the surface is under tensile strain.

8. Repeated stressing appears to reduce the magnitude of residual compressive stress.

9. Fatigue life of these specimens correlates directly with the magnitude of the residual compressive stress near the surface.

(Paper on which this abridgment is based will appear in full in the 1954 SAE Transactions. Paper appeared in full as Appendix K to the minutes of the Sept. 30–Oct. 2 meeting of Division XX—Shot Peening of the SAE Iron and Steel Committee, but is not available in preprint form.)

Refineries Can Now Make 98-Octane Fuel for Cars

W. M. Holaday, Socony-Vacuum Laboratories

Based on paper "What Can We Get from Higher Octane Number Fuels" presented at SAE Annual Meeting, Detroit, Jan. 13, 1954.

CATALYTIC reforming can upgrade poorest quality straight-run gasolines to an octane number level above that of present premium-grade gasoline. The resulting 98-octane fuel would, it is true, cost more to refine. But it could give more miles per motorist fuel dollar if high-compression engines and improved transmissions were developed. At the same time, there's a potential saving in a priceless natural resource—crude oil.

For some time now, engine designers have been using higher compression ratios to get greater specific power output and better fuel economy. But in almost every case, these increases in compression ratio have been dependent on the availability of higher octane gasolines.

The obvious desire for high octane gasolines has stimulated a tremendous amount of research by the petroleum industry. As a result, new refining techniques for the efficient production of high quality gasolines are now available.

Use of these processes for the manufacture of higher octane gasolines will necessarily alter the current gasoline price structure. A brief outline of current refining techniques will serve as background information for a study of the economics involved.

There are three main steps in the manufacture of gasoline:

1. Distillation of crude oil to separate it into gasoline, kerosene, distillate fuel oil, and gas oil fractions.
2. Cracking of gas oil to increase the volume of gasoline and distillate fuel.
3. Reforming of the gasoline fractions to raise their octane number.

Since reforming is the newest refining process used to upgrade gasoline octane number, let's consider it in more detail.

Following the pattern set in the course of the development of cracking processes, the first reformers were of the thermal type. Thermal reforming, however, results in considerable decomposition of the charge stock into gas. The loss in gasoline volume is not serious at the mild temperature and pressure conditions used to obtain moderate octane number increases. But at the severe conditions required to reach the quality level of present-day fuels, the losses increase rapidly. The resultant reduction of gasoline yield is an important part of the cost of octane number improvement by reforming. Polymerization can be used to convert part of the gas back to gasoline, but this, of course, adds to the cost of the operation.

Catalytic reforming grew out of the petroleum industry's recognition of the need for a more efficient process. This reforming process is carried out at relatively low temperatures. Therefore, undesirable decomposition reactions are minimized. The chemical changes brought about in catalytic reforming upgrade poorest quality straight-run stocks to an octane number level above that of present premium gasoline. And this is done without excessive loss to gas. To be more specific, the gasoline loss at any octane number is less than half as much for catalytic as for thermal reforming.

With so great an advantage, it appears that the catalytic reforming process will be used in all or nearly all refineries in the near future.

Still, the problem of producing high octane gasoline is one that will have to be met by refiners individually. No one fixed procedure will be applicable to all. As a result, no hard and fast statements can be made regarding the relationships between octane number, refinery operating methods, and fuel economics.

However, an example will be presented showing how present-day technology might be used in a completely new refinery to produce gasoline at current and expected future octane number levels. Also

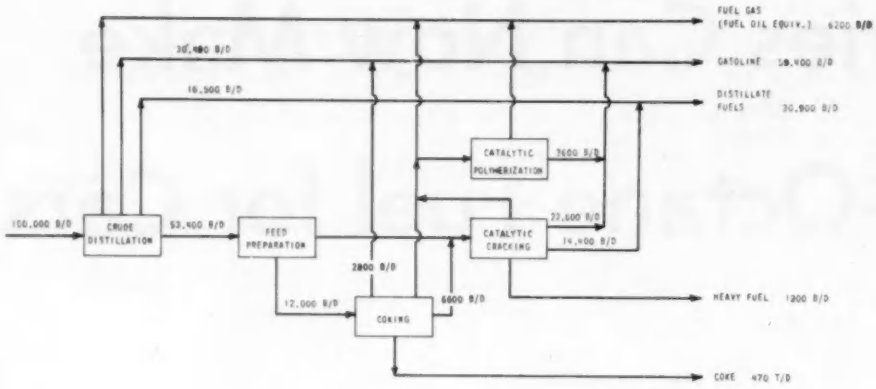


Fig. 1—This refinery could produce 59,400 bpd of 87 Research octane number gasoline (3 ml of tel/gal) from 100,000 bpd of Mid-Continent crude

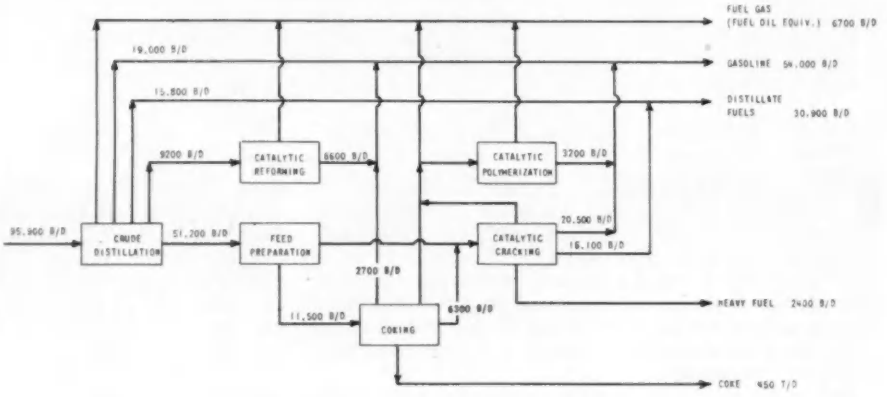


Fig. 2—This refinery could produce 54,000 bpd of 92 Research octane number gasoline (3 ml of tel/gal) from 95,900 bpd of Mid-Continent crude

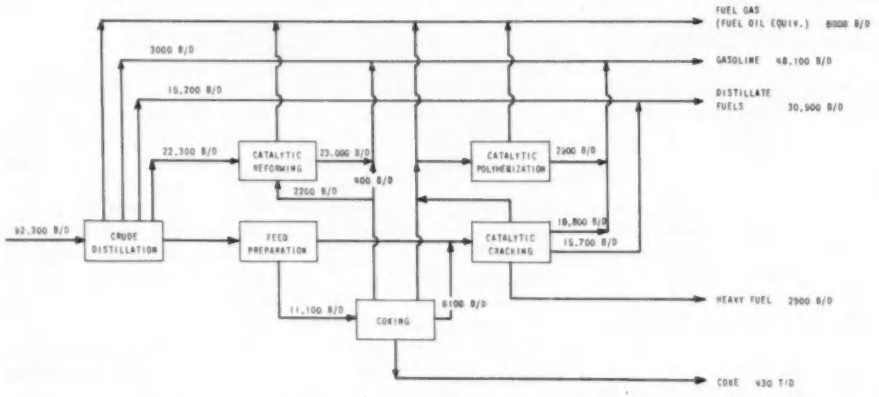


Fig. 3—This refinery could produce 48,100 bpd of 98 Research octane number gasoline (3 ml of tel/gal) from 92,300 bpd of Mid-Continent crude

considered will be the question of how crude oil utilization and fuel economics would be affected.

Figs. 1, 2, and 3 show diagrammatically how the refinery would be set up to produce gasoline with Research octane numbers of 87, 92, and 98 (all gasoline containing 3 ml of tel/gal).

Now, with the improved quality gasoline made available by reforming, fewer gallons of gasoline would be needed to give the same number of car miles obtained with 87-octane fuel. That's because more efficient engines could be used. (See Table 1.)

Still another significant point is that the crude

oil requirement would be reduced by 4.1% for the 92-octane gasoline and 7.7% for the 98-octane fuel, provided the higher quality is used efficiently.

Naturally, the costs associated with reforming (product loss, operating cost, and amortization of a rather sizeable investment) must be added to the cost of manufacturing the improved gasoline. However, on the credit side, there are the savings resulting from reduced crude oil requirement and the smaller volume of gasoline that must be handled throughout the distribution system.

Thus, there is a potential saving to car owners in the cost of a given amount of transportation—even though the price of the fuel per gallon is higher. Also, there is a potential saving in a priceless natural resource—crude oil.

But these potential savings will hinge on production of automobiles with high compression ratio engines and improved transmissions designed for economy.

We believe this is feasible. Does the automotive industry agree? Can a time schedule be set on availability of engines and cars having such characteristics? If so, our company is prepared to install new refinery equipment that will make fuels of this type available.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Table 1—Summary of Possible Results with Refineries Producing 87-, 92-, and 98-Octane Gasoline

	Refinery A	Refinery B	Refinery C
Research Octane Number	87	92	98
Permissible Compression Ratio	7.2 to 1	8 to 1	10 to 1
Miles per Gallon	14.0	15.4	17.3
Gasoline Requirement for Same Mileage bpd	59,400	54,000	48,100
Crude Oil Requirement, bpd	100,000	95,900	92,300

Excerpts from Discussion by . . .

D. F. Caris
Research Laboratories Division, GMC

BEFORE answering the question the author directs to the automotive industry, I would like to present a chart showing the progress made in engine-fuel relationships by one car maker since 1948. (See Fig. A.)

In 1948, this GM Division was still building an L-head engine. In 1949, it came out with a new overhead-valve engine—the prototype of the present engine.

As shown in Fig. A, there has been a 32% improvemen in Car C's position in relation to fuel economy since introduction of this new design. At the same time, the performance, as indicated by acceleration time from 10 to 60 mph, has improved 30%.

This is quite a significant achievement when you consider that during most of 1953 this car had the greatest horsepower of any car on the market. Also, it led the field in both fuel economy and performance despite the fact that it is a comparatively large and heavy car.

How has this been accomplished? There is no single answer. However, compression ratio has been increased 1.2 ratios. Octane number of gasoline has increased about four octane numbers on a country-wide average. And horsepower has increased 40% from 150 to 210.

Some of this improvement has been due to better fuel quality or chemical octane numbers; some has been due to built-in mechanical octane numbers. As an example of mechanical octane numbers, we can cite the improvement made since 1951.

While the average fuel octane number level for the country has gone up only one-half octane number, Car C has increased its compression ratio from 7.5 to 8.25 to 1. The mechanical octane numbers represented by this ¾ compression ratio increase involved changes in combustion-chamber design, valve timing, manifolding, carburetion, ignition timing, and transmission and rear-axle ratio.

Such progress in engine-fuel relationships is highly infectious in an industry as highly competitive as the automotive one. And I am certain that a similar trend will eventually be reflected in greater or less degree in all makes of cars.

Therefore, in answer to the author's question, I believe the automotive industry is in an excellent position to take full advantage of the 98-octane fuel he proposes to make.

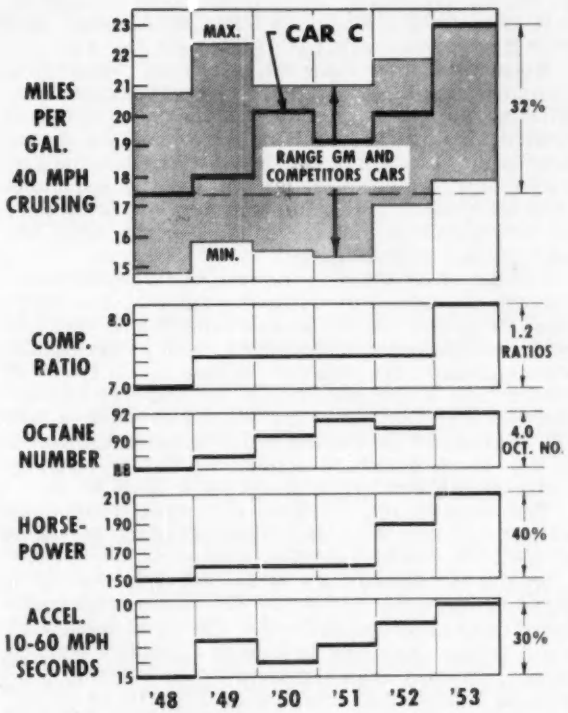


Fig. A—This shows the progress one car manufacturer has made in engine-fuel relationships since 1948

Jet Airliners FLY Across the

R. D. Kelly and H. B. Kaster, United Air Lines, Inc.

Based on paper "Simulated Jet Transport Operation" presented at the SAE National Aeronautic Meeting, New York, April 15, 1954.

EVERY morning an airline dispatch office in San Francisco plans the flight of a big jet transport in the 100-passenger class scheduled to take off at 7:25 a.m. Pacific Standard Time for Chicago and New York.

No such jet liner takes off, of course. Transports like this won't be available for several years at least. The flight plan is part of the make-believe that United Air Lines is practising to secure data on the practicality of commercial jet operations. The on-paper-only operation is answering the questions that arise when an airline considers buying a fleet of multi-million dollar jet transports—and the answers are encouraging.

Instead of listening to the roar of turbojets pushing the big transport down the runway, the flight planner quietly calculates the time it will take the plane cruising about 550 mph to reach a check point near Chicago. He also figures how much fuel will remain out of the total loaded for the trip and for reserve. (The jet plane carries enough reserve fuel so that it can hold for the same period and proceed to the same alternate airport as DC-6's actually being dispatched to the same destination.)

The information on time of arrival and gross weight the San Francisco dispatch office forwards to the UAL Chicago dispatch office.

At the calculated time of arrival over the check point, a receiving dispatcher determines the treatment to be accorded to the jet plane. If conditions don't permit the plane to land at Chicago's Midway airport, he may hold the airplane in a traffic pattern at a particular altitude or divert it to an alternate airport.

When the plane lands, the dispatcher notes the time and place of landing, the time and altitude of any holding, the amount of low-level maneuvering, and whether the runway was dry, wet, or icy.

The schedule allows time for refuelling and requires the imaginary plane to take off for New York at 1:45 p.m. Central Standard Time. Again the same calculations are made.

No "Breaks" for the Jet

No preference is given the jet. It is charged with the same ground delays, traffic restrictions, holding, and clearance to alternates as other aircraft in the area are experiencing. Freedom from mechanical difficulties is the only advantage accorded the hypothetical jet transport.

Besides the San Francisco-Chicago and Chicago-New York flights, there are four other hypothetical flights followed. One leaves New York at 1:10 p.m. Eastern Standard Time for Chicago and leaves Chicago at 2:50 p.m. CST for San Francisco. A nonstop flight leaves San Francisco at 8:30 a.m. PST for New York. And a westbound nonstop flight leaves New York at 1:10 p.m. EST for San Francisco.

UAL has been keeping records on these paper operations since the beginning of 1953. Here are some of the lessons learned from the first year:

Altitude—It's best to climb as high as possible, as soon as possible. That's because fuel consumption of the jet transports decreases so rapidly with altitude.

True, a westerly wind may be 50 mph stronger at 35,000 ft than at 40,000. And therefore on an eastbound flight you may save 5 to 10 minutes by cruis-

Country Daily—on Paper

A year of simulated jet operations indicates that

- **The highest altitude is the most economical one.**
- **Route detours into more favorable winds don't pay.**
- **Jet streams over the U. S. will have little effect on jet transports.**
- **Fuel reserve policy may need revision for jet operations.**
- **Jets can keep to schedules as readily as today's transports.**
- **Presently obtained wind data is adequate for flight planning.**
- **Runways at San Francisco, New York International, and Chicago's O'Hare Airports are not too short for jet transports.**

ing 5000 to 10,000 ft below the maximum altitude possible with the load. But this costs about 500 lb of fuel per minute gained.

Route—The regular airway or great circle route is most efficient. Detours into more favorable winds —even "jet streams"—usually don't save time or fuel. Where they do, the gain is too slight to justify resulting minor traffic problems.

In general, the airflow at 35,000 or 40,000 ft above the United States is a nearly straight westerly wind of 50 to 75 mph. Occasionally the stream meanders toward the south, then back and to the northeast.

Within the main stream there are usually one or more lines along which flow appears to be faster than the general flow. (Some meteorologists call these lines "jet streams" when flow is above a certain speed. Some use the term when wind shear exceeds some specified value which varies with altitude. Others apply the term to the axis of greatest wind speed, regardless of the magnitude of speed or shear. There is no standardized definition of the term.)

On a rare day, velocity in one of these fast streams may flare up to 200 mph for a few hundred miles. But 40 to 60 mph above mainstream velocity is more usual.

If a jet plane finds itself going with one of these high winds, fine. If the plane is flying into the wind, it might just as well stay on course. An increase of 40 to 60 mph in head wind for 20 minutes adds only a few minutes to flying time. This is less time than it would take to skirt such an area, even if its exact location were known.

Fuel Reserves—Maybe we should review present fuel reserve policy developed for piston engines before we apply it to jets.

Please turn page

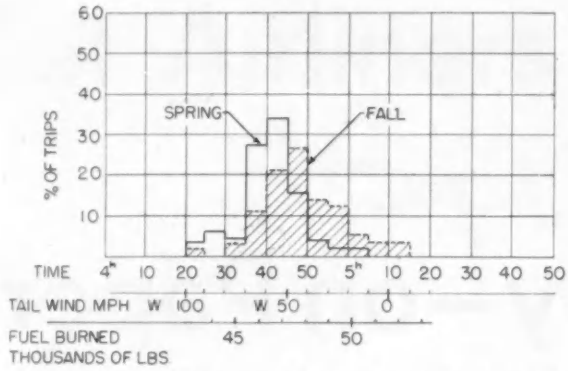


Fig. 1—Performance of the nonstop San Francisco-to-New York flight

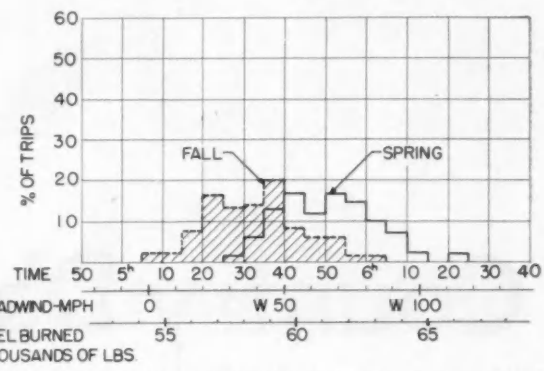


Fig. 2—Performance of the nonstop New York-to-San Francisco flight

Jet transports being designed now are planned to carry reserve fuel for the same amount of holding time as present transports do. Therefore in the UAL paper operations, when an alternate is required, fuel beyond that needed for climb, cruise, and descent to destination is carried to take care of:

- Reserve of 5% of the trip load,
- Holding over destination for 45 min,
- Maneuvering at low altitude for 5 min,
- Climb-out and cruise at 20,000 ft to alternate
- Descent to alternate
- Reserve in tanks at landing for 45 min,

If the weather is clear and the visibility unlimited over the destination, no fuel for holding or for flight to alternate destination is needed. But the fuel load covers not only climb, cruise, and descent to destination, but also:

- Reserve of 5% of the trip load,
- Maneuvering for 5 min at low altitude,
- Reserve in tanks at landing for 45 min,

Adhering to this policy causes the nonstop jet flights to carry fuel reserves averaging more than half the full payload on eastbound trip. Westbound flights average reserves approximating one-third the maximum payload.

Amount of reserve fuel used was negligible in comparison with the amount of reserve fuel carried.

Flights did land at alternate airports such as Boston, Philadelphia, Cleveland, or Sacramento on eight days during the year. But always such irregularities had been anticipated. Always there was more than an hour's reserve fuel on board at the landing.

During the course of a whole year of operation, only one flight was held for as much as an hour. Only on 16 days did traffic require holding for as long as 20 to 40 min.

All flights landing at Chicago had 13,000 lb or more fuel on board. A mere 2% of Chicago-bound trips used an appreciable amount of reserve fuel. The greatest amount ever used was only 5000 lb.

Unforeseen difficulties have less time to develop when jets are used because there's less time between the jet's departure and arrival.

Schedules—The range of arrival times is small, even though the times are based on the assumption of constant power. Figs. 1 and 2 illustrate this point. They give the distribution of flight times for the nonstop flights during the periods August-September-October and February-March-April, the seasons of weakest and strongest winds, respectively.

Adjustments in power would narrow the range of arrival times further.

An airline operator can set his schedules according to the flight time equaled or bettered in 85% of the cases, and be confident that the deviations will be slight.

Wind Data— The present observing network provides adequate wind data for planning jet transport flights.

We don't get as many wind reports from the 35,000 or 40,000 ft levels as from the lower levels. But we can plot the broad flow of air at these high levels. In fact, we can do it better than we can plot the many clockwise and counterclockwise circulations and frontal wind shift lines which clutter the maps for lower levels.

A given variation in wind is a much smaller percentage of the airspeed of a jet transport than that of slower, low-altitude aircraft.

Runway Lengths—The 8900-ft runways at San Francisco never restricted payload. At New York International (Idlewild), payload of the transcontinental nonstop flight was restricted by several thousands pounds on half a dozen summer days. On these occasions unusually high ambient temperatures limited climb performance.

The Chicago Midway runway length is only 6300 ft. The new O'Hare Airport there, with its longer runways, will be much better for jet transport operations.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Better Superchargers Bring Wider Usage

RECENT developments in the supercharging field include:

- High-pressure turbosupercharging of diesel engines.
- Improved methods of turbosupercharging 2-stroke diesel engines.
- Supercharging of small, automotive engines.

• Supercharging 4-Stroke Diesels

A high-pressure turbosupercharger suitable for use on heavy-duty diesel engines is shown in Fig. 1. This unit, which is made by De Laval, is capable of providing the high pressure because it has a high combined efficiency.

The design is radically different from that of conventional turbosuperchargers. It employs a new design of mixed-flow compressor of very high efficiency and an aerodynamically improved centripetal turbine.

Rotor construction is also unique. Compressor impeller and turbine wheel are combined in a single rotor structure. Having the compressor blading on one side of the rotor hub and the turbine blading on the opposite side does away with nonworking surfaces. As a result, all parasitic losses (such as windage and friction) are eliminated and compressor and turbine leakage is avoided. The elimination of these losses means that the efficiencies of turbine and compressor are substantially improved, over and above the improvements already achieved by the aerodynamic refinement of the blading. This Monorotor construction—as it is called—is also extremely simple. It eliminates a great number of parts, such as air and gas seals and partition walls.

The turbine nozzle guide vanes of the centripetal turbine can be located between two radially extending walls. This makes it possible to arrange for easy adjustment of the turbine nozzle areas.

There is available with the De Laval supercharger a simple mechanism that permits external adjustment of the nozzle guide vanes during operation of the supercharger-engine combination. Use of this external adjustment can be made for a variety of

This article is based on two papers presented on air supply to the engine at the SAE Annual Meeting, Jan. 15, 1954. They are:

- "New Developments in Turbocharging," by RUDOLPH BIRMANN, De Laval Steam Turbine Co.
- "Development of McCulloch Supercharger for Automotive Diesel and Gasoline Engines," by JOHN W. OEHRLI, McCulloch Motors Corp.

These papers are available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ each to members; 60¢ each to nonmembers.

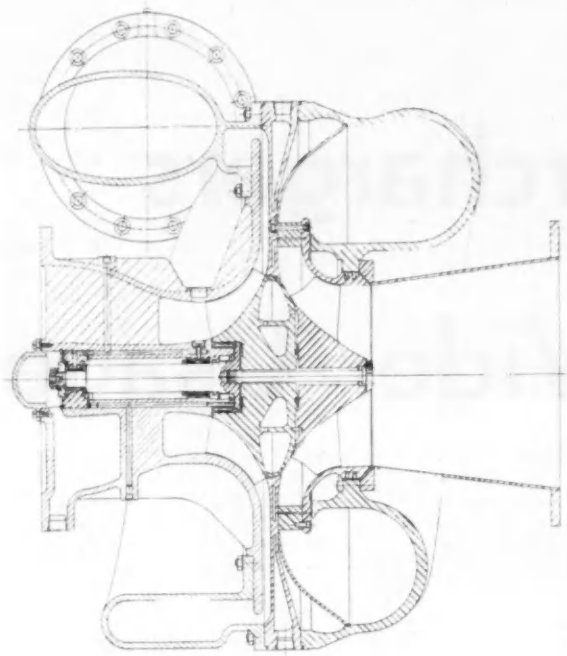


Fig. 1—De Laval high-pressure turbosupercharger for heavy-duty diesel engines (from Birmann)

purposes, including the achievement of high supercharger rpm under conditions of low engine rpm. High engine torque is thus obtained during low-speed engine operation.

The constant-pressure system of connecting the engine to the turbine is used in the unit shown in Fig. 2. This illustration shows an 8-cyl, 13 × 16½-in. Nordberg diesel engine. The exhaust gases from all the cylinders are collected in a common manifold, which delivers them to the single turbine inlet of the supercharger. The exhaust manifold is large enough to act as a plenum chamber, where practically constant pressure is maintained.

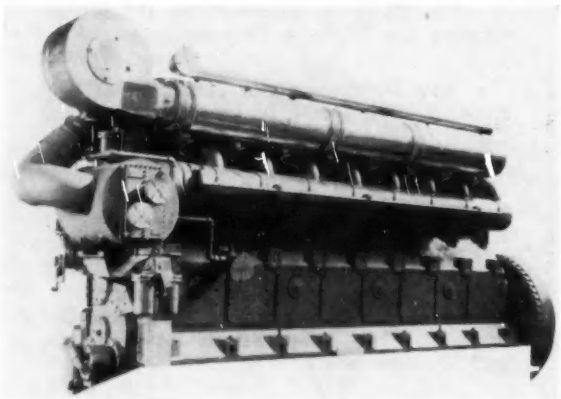


Fig. 2—1800-hp Nordberg diesel engine with De Laval high-pressure turbosupercharger (from Birmann)

The single exhaust manifold of the constant-pressure system is much simpler and more reliable than the complicated multibranched manifolds required for the blowdown system. It is also much cheaper to manufacture.

The constant-pressure system also facilitates the achievement of high turbine efficiency by permitting operation of the turbine with full admission and as the steady-flow device it was meant to be.

In addition, a "pulse converter" is provided to combine high turbine efficiency (derived from steady-flow operation) with use of pulsating energy (an advantage of the blowdown system).

The pulse converter converts the pulsating energy in the exhaust gases into a pressure rise. The energy in the exhaust pulsations is thus made available to the turbine in the form of increased pressure, under conditions of full admission and steady flow.

Fig. 3 shows this arrangement for a 4-cyl engine. Cylinders 1 and 2 (which have noninterfering exhaust phases) discharge through manifold branch A into primary nozzle C of the pulse converter. Cylinders 3 and 4, whose exhaust phases are likewise noninterfering, discharge through manifold branch B into primary nozzle D. At any moment the rapidly fluctuating pressure in one of the two exhaust manifold branches reaches a maximum. This pressure is converted into high velocity in the primary nozzle pertaining to this manifold branch.

The high velocity exerts an eductor effect on the other branch. By momentum transfer between the high-velocity and low-velocity gas streams (ejector and eductor flows), a fairly uniform high velocity is maintained in the mixing section 5. This high velocity corresponds to a low static pressure, which is the back pressure "felt," so to speak, by the engine.

The high velocity in the mixing section is then converted (in the diffuser 6) into a pressure rise, augmenting the output of the turbine. It can, therefore, be seen that, in common with the constant-pressure system, the turbine operates under conditions of steady flow and full admission. The action of the pulse converter causes the pressure in the turbine nozzle box to be practically constant. It is also substantially higher than the mean of the fluctuating pressures in the exhaust manifold branches. This pressure rise represents the energy from the exhaust pulsations that is made available to the turbine.

• Supercharging 2-Stroke Diesels

Two improvements in the turbosupercharging of 2-stroke diesel engines are:

1. A better way of maintaining a positive differential between intake and exhaust manifold pressures under starting and light load.

2. A method of lowering the engine flow resistance of the loop-scavenging diesel engine, so that it can be adapted to turbosupercharging.

Suitable manifolding is helping to make the turbosupercharger the sole and unassisted source of air supply to the 2-stroke engine under all conditions of operation. Burmeister & Wain (the leading Danish 2-stroke-engine manufacturer) has built at least one 2-stroke marine diesel with a Brown Boveri turbosupercharger operating freely and without any assistance from the engine.

This system seems to be a definite improvement over other ways of assuring pressure difference, such as the introduction of engine crankshaft power to the turbosupercharger rotor shaft during starting, idling, and at light load. These methods require gearing, an overrunning clutch, or the like, and thus are complex and expensive. These same disadvantages are also true for the system of lightening the turbine load by providing an engine-driven positive displacement blower, either in series or parallel with the exhaust turbine driven compressor.

In the Barnes & Reinecke 2-stroke loop-scavenged engine, engine flow resistance is reduced to the low values possible with the uniflow type by arranging the inlet ports, as well as the exhaust ports, over the full circumference of the cylinders, as shown clearly in Fig. 4.

This technique, which allows the 2-stroke loop-scavenged engine to be turbosupercharged, may well revitalize this type of engine, with its unsurpassed simplicity of construction.

• Supercharging Small Automotive Engines

Recently, there has been a trend toward the supercharging—including the turbosupercharging—of small automotive engines.

The art of making highly efficient small turbosuperchargers, capable of high pressure ratios and so designed that they lend themselves to low-cost production, is rapidly being mastered. This is expected to start a trend toward turbosupercharging relatively small engines—engines that, in many respects, are even better suited to high-pressure turbosupercharging than are their larger counterparts.

This suitability can permit high-pressure turbosupercharging to bring about increases in the outputs of small engines, improvements in their fuel consumption, and reductions (on a per bhp basis) in weight, size, and manufacturing cost of a magnitude that may seem visionary to some at this moment. Moreover, high-pressure turbosupercharging can help in attaining greatly increased torque at low engine rpm. This could make the piston engine far more suitable for service in road and off-highway vehicles—one of its major fields of application.

Meanwhile, another solution to the problem has been the development of the McCulloch belt-driven centrifugal supercharger, which is suitable for both diesel and gasoline automotive engines in the 100–200-hp range.

This centrifugal unit has variable-speed drive with pneumatic control to provide:

1. Maximum air pressure over a wide operating range.
2. Protection against overspeed.
3. A lower-speed economy range.

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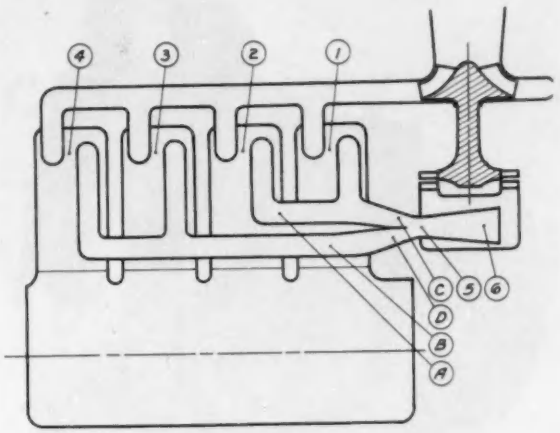


Fig. 3—Schematic arrangement of De Laval pulse converter (from Birmann)

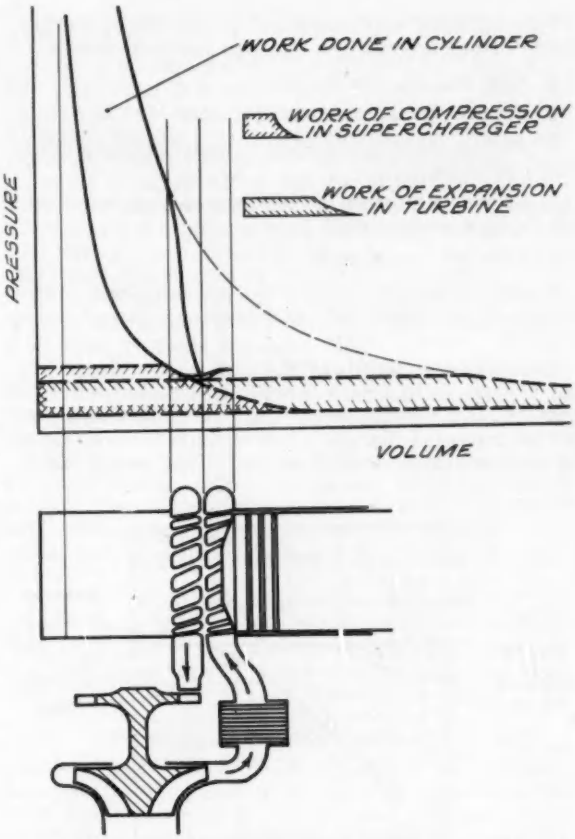


Fig. 4—Schematic illustration of loop-scavenging 2-stroke engine with high-pressure turbosupercharging (from Birmann)

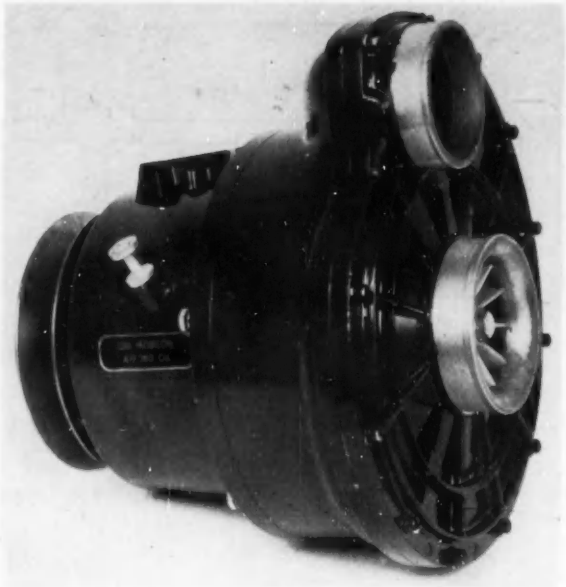


Fig. 5—McCulloch supercharger for automotive diesel and gasoline engines (from Oehrli)

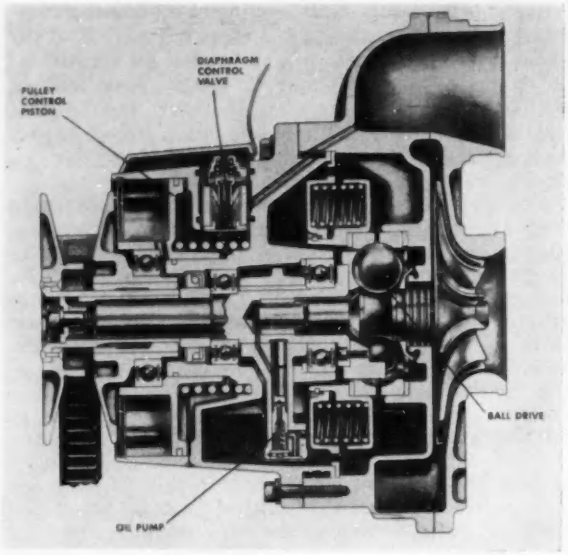


Fig. 6—Cross-section of McCulloch supercharger (from Oehrli)

Fig. 5 shows a photograph of the supercharger. Some of the advantages claimed for it include:

1. Low manufacturing cost.
2. Flexible pressure characteristics.
3. Independent lubrication system requiring minimum attention.
4. Service life equal to modern engines with virtually no maintenance.
5. Very low noise level.
6. One production model suitable for the entire range of passenger cars and the majority of truck engines.

Construction details of the unit are shown in Fig. 6. Power from the engine crankshaft pulley is transmitted directly to the only variable-speed pulley on the supercharger. Belt tension is maintained by a spring-loaded idler pulley. This power forces the belt into high ratio against the spring on the splined slidable driven pulley. With the accelerator wide open, the pulley remains in high ratio until the maximum supercharger outlet pressure is obtained. As this engine and supercharger speed is reached, the diaphragm control valve admits supercharger outlet air to the pulley control piston. The effect of this is to reduce the drive ratio and maintain the desired maximum pressure when engine speed is increased. At the same time, the control prevents overspeeding stresses in the impeller.

When cruising speed is attained, the reduced accelerator setting opens the control valve, bypassing air directly from the supercharger to the pulley piston. The supercharger speed and discharge pressure are thereby reduced. The pulley piston requires only 1–2 psi for control.

Response of this pneumatic control is quite fast and keeps the supercharger in a standby condition until it is needed.

Type A automatic transmission oil is used in an oil system independent from the engine. The oil is pumped from the self-contained reservoir to the centering bushing at the inner end of the impeller shaft. From there it flows on the ball driver fingers and through the ball races.

It was found that the unit ran as cool as with a mist spray and provided forced lubrication where needed. Oil is prevented from leaking around the impeller shaft by permitting a small flow of air to be forced into the drive compartment and out through a small orifice at the input shaft seal. It must flow against centrifugal force to separate any large oil particles. Mist passing this point lubricates piston rings in the air control cylinder. The sliding pulley member contains a self-lubricated spline, which receives no reversed loads because the V-belt also contacts the fixed pulley member.

Fig. 7 shows torque and horsepower curves for a typical gasoline engine, with and without the McCulloch supercharger.

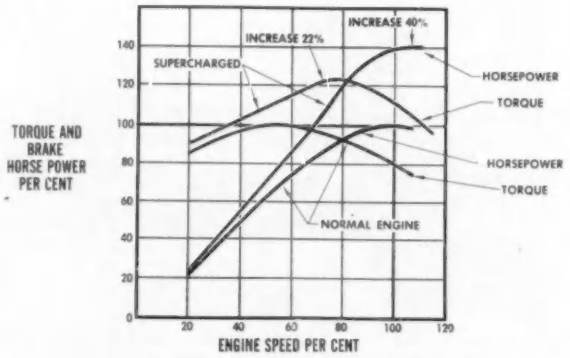


Fig. 7—Engine performance comparison—typical gasoline engine at full throttle with and without supercharger (from Oehrli)

BEA Planes Stow Away Less Fuel and More Payload

K. G. Wilkinson and J. Vivian,
British European Airways

Based on paper "A Rationalized Fuel Reserve Policy for Medium-Range Airline Operations" presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 2, 1953.

BRITISH European Airways has found a way to carry more payload on medium-range flights. No longer are fixed seasonal amounts of fuel loaded into planes making the same run. Instead, BEA now calculates the fuel required for safe operation of a particular flight. Result: Less fuel goes along just for the ride and more payload goes along in its place.

Actually, long-range operators have always used a variable fuel method. The practical operational techniques required with such a system, therefore, are well known. But they usually are not applied to short-range operations if the aircraft can carry capacity payload with ample reserve fuel. High-density seating on smaller aircraft can, however, make quite short runs repay the trouble of the variable fuel method.

BEA, therefore, set itself the task of studying the practicability of various pre-departure forecasts. The aim was to work to a calculated risk at all stages, relating the final operational rules to factors susceptible to review and revision.

In the method developed, the fuel calculated for each flight is made to depend on pre-flight forecasts of wind along the route, plus visibility and cloud base at the intended destination and alternate airfields. This calculation, in turn, must be consistent with a control procedure used in flight to inform the captain of his fuel state; hence, the action he is free to take without jeopardizing safety.

From the beginning of a flight, the question is always present: Should the flight continue to its destination, make an intermediate stop, or divert? The quantity of fuel left, the distance remaining, and the expected terminal conditions will determine what to do.

Rules of behavior, therefore, had to be postulated. It was decided that the flight crew would maintain a "howgozit" chart.

This chart would show the fuel consumed against the time out. It would also indicate the estimated time of arrival at an alternate point, flying via the intended destination, taking account of found and expected wind. (Weather at this alternate field must be reported above the acceptable minimum.) The fuel time line extrapolated would have to show arrival at the alternate field with a given margin of fuel left in the tanks. (See Fig. 1.) If at any time the chart failed to show the required margin, then, with no other alternate available or the intended destination not certain to be open, an intermediate stop must be made for more fuel.

In short, at the point where a decision is made, the crew must know that it has sufficient fuel to reach the finally selected terminating point for the flight.

With the safety of the operation guaranteed by a rigorous flight-control procedure, the function of the pre-flight calculation is to ensure that the flight will arrive at its intended destination, without technical stop, a sufficiently high percentage of occasions.

Fuel to be loaded, therefore, depends on the margin to be allowed subsequently in the in-flight check. To this margin must be added an amount that will take care of uncertainties from the start of the flight to the time of the critical check.

Alternate Field Designations

Since the in-flight check is made with an alternate destination in mind, the pre-flight calculation must also assume an alternate. In the BEA system, a particular alternate is designated on the following basis:

- **Rule I**—If good weather (visibility at least 3 nautical miles and cloud cover not more than 4/8

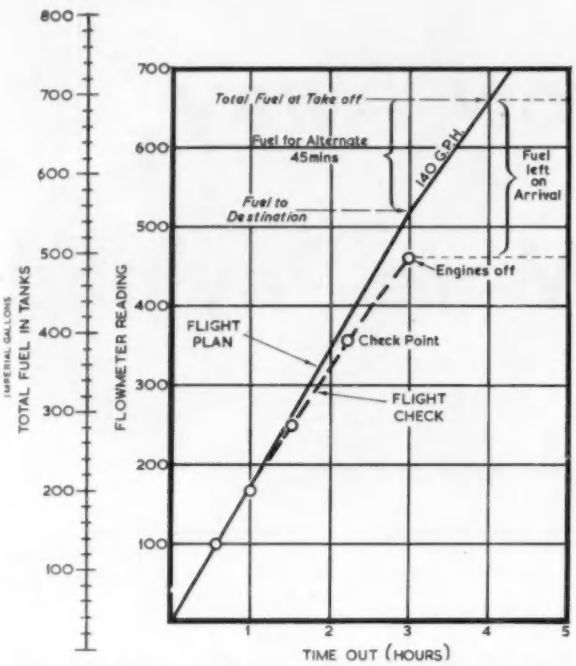


Fig. 1—Safety of BEA's variable fuel method is ensured by the crew maintaining a "howgozit" chart

below 2000 ft) is forecast for the neighborhood of the destination, the designated alternate is the one nearest the destination that is suitable for a landing. The airfield so chosen is known as the Rule I alternate.

• **Rule II**—If the forecasted weather at the destination and near alternate is below Rule I minima, then the next nearest alternate at which weather above these limits can be expected is selected. The Rule II alternate is selected from a relatively short list of suitable airfields.

An investigation of terminal forecasting accuracy showed that only 1% of the time would a flight encounter worse conditions than those on which the pre-flight plan was based. Hence, only 1% of the time under Rule I flight would conditions at the terminal be sufficiently different to make landing there doubtful.

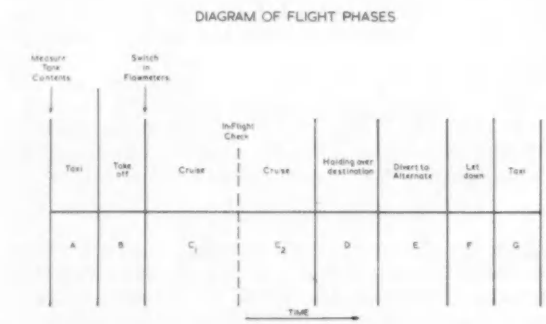


Fig. 2—This diagram shows the various flight phases that enter into the in-flight check

The In-Flight Check

Now, keeping this in mind, let's consider what enters into the in-flight check.

Such a check is made after phase C, one hour before scheduled arrival at destination. (See Fig. 2.) Fuel is required at this point for (1) cruising to destination, phase C_2; (2) let down, phase F; and (3) final taxiing, phase C_T. In addition, these two possibilities must be taken into account: (4) holding over destination, phase D; and (5) diversion to alternate field, phase E. Finally, the exact amount of fuel left in the tanks will not be known due to (6) errors in the initial fueling process, (7) uncertainty as to the amount of fuel used while taxiing and taking off, phases A and B, and (8) errors in flowmeter reading of fuel used during phase C_1.

None of these eight components can be known exactly in any one case. But they can each be represented by a probability distribution. These distributions, in turn, can be combined so that the overall probability of needing more than a given amount of fuel can be stated.

Risk Level of 1 in 10,000

To arrive at a rule for everyday use, an arbitrary choice of risk level had to be made. BEA selected a level of 1 in 10,000. Thus, if a captain elects to divert from overhead at destination (after a fuel check at the beginning of phase C_2 has shown bare ability to reach the alternate field with the required margin), the chances are 1 in 10,000 that there will not be enough fuel. Since BEA has about 600 diversions a year from overhead at destination, this means there would be less than one such mishap every 17 years.

Actually, the chances of such a mishap occurring would be even less than this because:

1. The captain is not bound to follow the rule slavishly. Rather, he is encouraged to exercise his judgment, using the rule as a basis for his decision. There is a good possibility, therefore, that he will spot the time in ten thousand when everything is against him.
2. The crew will probably know if a large amount of fuel has been used in phases A and B, and will be able to adjust accordingly.
3. On many occasions, particularly in winter, the flight will be able to depart with more than the minimum calculated quantity of fuel.
4. Fuel consumption can be reduced in most cases by adjusting cruising and holding procedures.
5. In an emergency, the captain can ask for priority in landing.

In figuring the in-flight margin, the most important sources of variation are holding time, wind forecast errors on diversion, and errors in fuel actually on the aircraft at the check point.

It has been found that the probability distribution of holding time over all destinations is approximately exponential in form. The times for phases A, B, F, and G also were found to be exponential in form, though of lesser importance than holding

time. These five distributions were accordingly combined into a single x^2 distribution, times being converted to equivalent fuel before this was done.

Fuel needed for phase E, the diversion, has a normal probability distribution whose standard deviation corresponds to the standard error of the wind forecast.

Surprising as it may be, fuel actually on the aircraft at the check point is an important source of error. What's more, it is one that is cumulative from the beginning of the flight.

Here's why. Even before the engines are started, the fuel in the tanks is not known exactly. (To account for this, the following allowances are made: Viking—10 gal, Elizabethan—20 gal, and Viscount—20 gal.) After take-off, however, the fuel remaining is even less definitely known. For one thing, fuel flowmeters are not 100% accurate. For another, the flowmeters are not switched on until after take-off because a flowmeter failure could conceivably restrict the fuel flow to an engine at take-off power.

These probability distributions, when combined, permit a fuel quantity to be picked off that will be sufficient to complete flights diverted from overhead in all but one case out of 10,000. This quantity can be expressed as the mean fuel required to reach destination and divert to alternate with T minutes to spare. "T minutes" (the conversion being made at cruising consumption) is then the in-flight margin.

The value of "T" will depend on the terminal considered and the season of the year. BEA practice is to round off "T" to the next multiple of 15 min.

Now, the fuel loaded onto the plane must not only satisfy the in-flight check, it must also be sufficient to cover the fuel burned during phase C_1.

The quantity of fuel that will be burned during phase C_1 is not known exactly. Factors that have an effect on this are wind forecast errors, airframe drag, engine power, specific consumption, aircraft laden weight, altitude, route mileage, outside air temperature, and flowmeter errors. Combined coefficient of variation due to these nine causes is 6%.

To keep the probability of the need for a technical stop down to 1/200, an additional quantity of fuel equivalent to 15% of the average consumption during phase C_1 is loaded.

On some sectors (particularly long sectors terminating at congested airports), the pre-flight fuel margin or stand-off allowance is so great at the 1 in 200 risk level that an upper limit of 90 min has been set.

This method results in the provision, if need be, of a separate payload figure for each flight. Of course, if payload is not available until the last minute, the chances of it being carried are fairly remote. Also, the reservations branch will want to know what to use for advance booking, in some cases four months ahead of the flight.

BEA, therefore, has run trials on systems providing a forecast 24 hr before take-off and, more recently, 3 hr before take-off. The attempt to forecast the payload for each flight 24 hr ahead has been a failure. While it is too early yet to give a final verdict on the 3-hr-ahead system, it appears that it can give maximum payload consistent with the chosen levels of safety and regularity.

Whether the fuel reserve policy described can be profitable depends on individual circumstances. It is quite conceivable that no benefits at all would be obtained at a conservatively selected risk level.

Table 1—Increase in Payload Since Introduction of New System

Services	Summer 1952		Winter 1952/3	
	Seasonal	Seasonal + PFF[a]	Seasonal	Seasonal + PFF[a]
Viking:	%	%	%	%
Day	+5.7	+8.0	+4.3	+2.7
Night	+2.3	+4.2	+1.0	−0.7
Total	+4.9	+7.1	+3.4	+1.8
Elizabethan:				
Day	+3.5	+5.0	+4.2	+2.8
Night	+5.5	+8.1	+2.4	+1.0
Total	+4.2	+5.4	+3.4	+2.2
All Services	+4.7	+6.6	+3.4	+1.9

[a] PFF = extra payload from pre-flight forecast

BEA's Results with System

Be this as it may, the results that BEA has obtained should be of interest. Table 1 shows the percentage increase in payload since the introduction of this new system. Note that during the summer about two-thirds of the increase was made available as seasonal payloads, and therefore was able to be offered to the public on a long term basis.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

Question: Do flight crews themselves calculate the reserve fuel that will provide the operational probability of an incident once in every 10,000 flights?

Answer: BEA pilots are given a rule-of-thumb by which they compute the fuel reserves that will give this incident probability.

Question: Does temperature variation affect the fuel planning?

Answer: Temperature is important with jet airplanes. It is primarily the enroute temperature that must be taken into account.

Question: Do timesavings due to the higher speed of turbine aircraft make fuel requirement prediction more accurate?

Answer: It is difficult to generalize in regard to the effects of speed of an aircraft. However, it is believed that variations experienced in fuel planning would decrease as the speed of an airplane increased.

Question: What percentage of fuel consumption variation is allowed for traffic control of flights?

Answer: BEA has found an allowance of 1% to be adequate. For wind variation, 4½% is used. The problem of different assigned flight routes would be more critical in the U.S. than in Europe.

Behind the Firebird Car's New Look . . .

. . . are new engineering twists in the body which sheaths this new powerplant and the chassis that cradles it. (Last month SAE Journal described the gas turbine which powers this Firebird car of GM's.)

1. Firebird Body:

Plastic Goes Aerodynamic

R. F. McLean, Styling Section, General Motors Corp.

Based on paper "An Aerodynamic Design in Plastics—The Design of the Firebird Body," presented at SAE Summer Meeting, Atlantic City, N. J., June 9, 1954.

IN road tests to date at moderate speeds, the Firebird car has behaved as predicted in wind tunnel tests . . . no undue lifting or yawing forces. The car cruises easily at speeds over 100 mph. Its plastic body is free from vibration, shows no heat distortion, and seems to be sufficiently rigid and strong for any vehicle operating conditions.

The car pretty well fulfills the criteria established at the outset for this high performance, special purpose vehicle. They were:

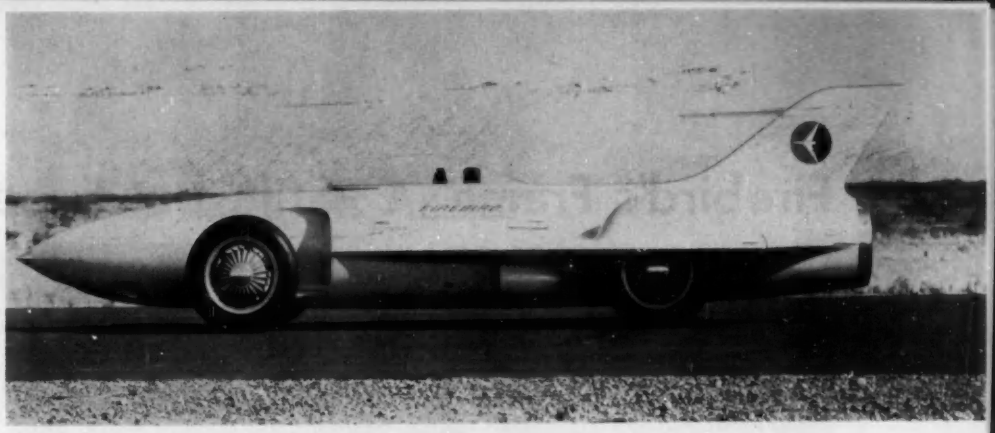
1. A shape or style that symbolizes the new powerplant.
2. Minimum frontal area and exceptional aerodynamic cleanness.
3. Stability at all speeds, with adequate margin.
4. Good weight distribution, with generally equal front and rear wheel reactions.

To fit these four objectives, the car was designed to house a single passenger, with the engine behind the driver. The driver sits beneath the plastic canopy. The design is unique in that it is just as fully enclosed and finished on the underside as on the top.

Despite its aerodynamic appearance and delta shape, the car will not become airborne. Study shows that maximum lift possible is only 45% of gross vehicle weight.

Air for the driver's compartment is taken in at the openings on the underside of the nose, just forward of the front tires. Circular ducts for engine exhaust cooling air are on each side just forward of the rear tires. On the left side, the air is first directed into a transmission oil cooler, after which it assists in exhaust cooling.

Turn to page 45 for a pictorial review of the Firebird's body development.



2. Firebird Chassis: *Safety at 200 miles per hour plus*

Robert Schilling,

Research Laboratories Division, GMC

Based on paper "A Cradle for New Power—Chassis Features of the Firebird," presented at SAE Summer Meeting, Atlantic City, N. J., June 9, 1954.

FROM the chassis designer's viewpoint, the outstanding fact about the Firebird is that it weighs about 2800 lb and has nearly 400 hp available. That means it's capable of speeds of over 200 mph. It must be possible to accelerate, drive, and decelerate safely at these speeds.

Interpreting this in terms of detailed requirements led to the following ground rules for the Firebird's chassis design:

1. Directional stability must be good at all speeds.

2. The brakes must be unusually good in control and in heat dissipation. Despite its modest weight, at the potential top speed the car will have several times the kinetic energy of a Cadillac.

3. There is no need for a smooth boulevard ride or for ability to handle rough roads. The car will be used only on reasonably level surfaces.

4. Road noise and harshness need meet only minimum standards.

5. Durability requirements also are moderate. A 10,000-mile life on good roads should be sufficient.

6. Where possible, all chassis parts should be located inside the body skin to reduce air drag and to maintain appearance.

7. The car need not be designed for easy production and low cost.

8. To take advantage of the opportunity to experiment, as many novel features as possible should be used, as long as final performance is not jeopardized.

Table 1 presents some of the Firebird's specifications. Some of the unusual chassis features are detailed on the following pages.

Table 1—Main Specifications of the Firebird

Over-all length	222.7 in.
Over-all width	80.0 in.
Height to top of bubble	41 in.
Height to top of vertical fin	55 in.
Ground clearance	4½ in.
Wheelbase	100 in.
Thread, rear	50 in.
Thread, front	54 in.
Tire size	6.70-16
Rim section	5K
Frame—Welded all box member 2 × 5 × 1/16 maximum section.	
Front Suspension—Double wishbone, with torsion bar spring and ball joint steering axis.	
Rear Suspension—De Dion, longitudinal single leaf springs with lateral balance beam.	
Steering—Recirculating ball type with parallelogram linkage, 20:1 over-all ratio.	
Brakes—Hydraulic, twin wheel cylinders with all forward energizing shoes. Brake drum of finned aluminum casting on cast iron insert, 11 × 2.50 in.	
Weight, empty	2440 lb
Weight, loaded (driver and 35 gal fuel)	
front	1315 lb
rear	1485 lb
	2800 lb
Static ride deflection	
front	2.75 in.
rear	2.50 in.
Ride clearance (front and rear)	
bump	2.00 in.
rebound	2.50 in.

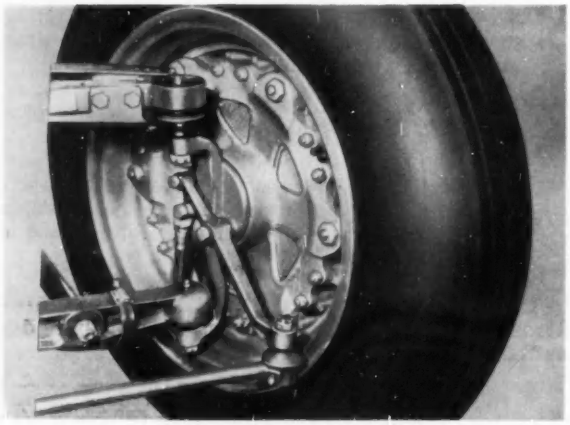
Firebird's Frame . . . Stiff, but Expensive

The frame front is pointed to fit inside the body contour and is padded with sheet rubber on the fuel tank mounting areas. The side rails widen toward the rear and have a long and easy kick-up, which fits them into the horizontal stub wing surfaces between body and rear wheels.

There are six crossmembers, the last one being behind the rear wheels. This extends beyond the side rails and carries the hinges and operating elements for the split flap air brakes. Side rails and crossmembers are all-welded box members with a maximum section of 2×5-1/16 in. Although this construction is expensive, it produces a frame high in stiffness, low in weight.

Brakes and Wheels Unusual for Passenger Cars

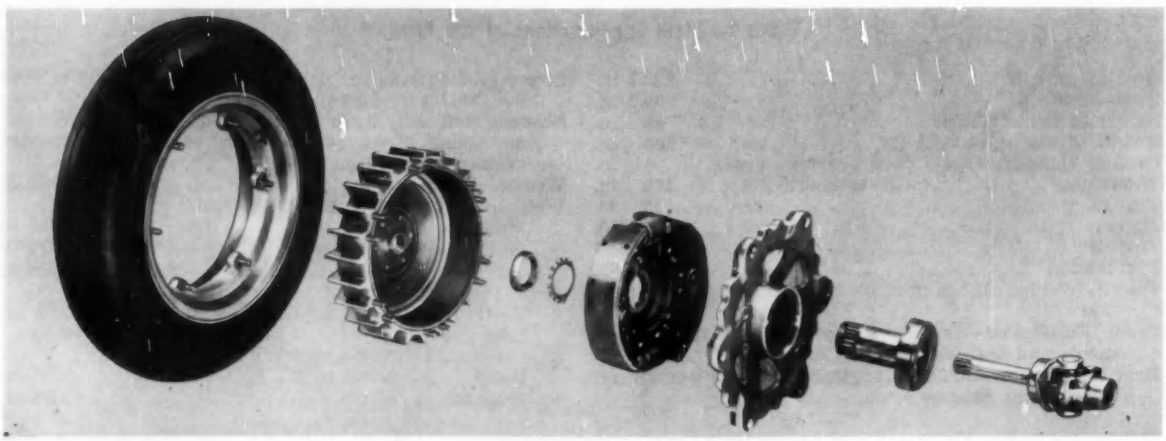
The unusual wheel and brake arrangement is similar to one developed by GMC for Ordnance vehicles. It's used for the Firebird because of the excellent airflow over the brake drums, giving good heat dissipation.



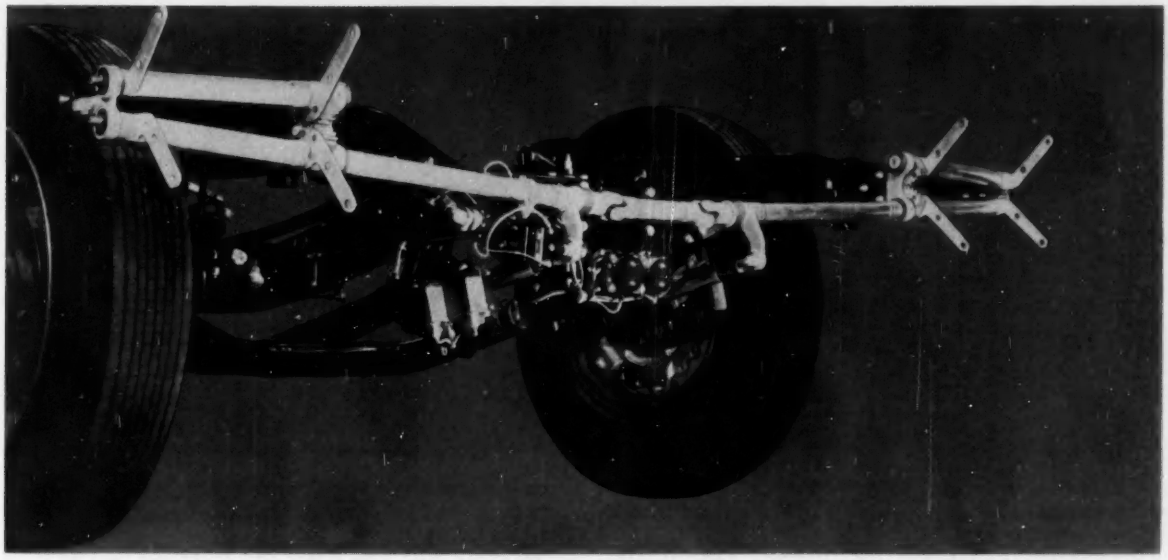
Components shown in the exploded view in the bottom photo are, right to left:

- The stub drive shaft with universal joint. This fits into the bore of the . . .
- Rear wheel spindle. This spindle is permanently bolted to the end flange of the axle tube, not shown.
- The six-spoked wheel is an aluminum forging. Wheel bearings and seals are mounted in its bore.
- Brake cylinder and shoe assembly form a complete preadjusted unit.
- Lock washer and nut hold brake assembly and wheel bearing inner races in place.
- Brake drum has a cast-iron rubbing surface over which a ribbed aluminum drum is cast.
- The rim is also an aluminum forging and fastens with six studs to the wheel.

The view at left shows the left front wheel assembly. It reveals the wheel to rim and wheel to brake drum bolting in more detail. Also visible is the front wheel spindle with its two extensions and the mounting of the steering arm.



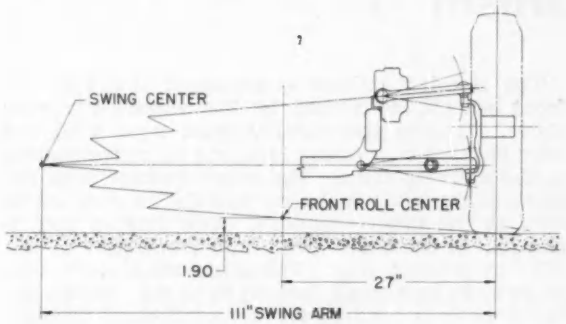
Flaps Give Wheel Brakes an Assist

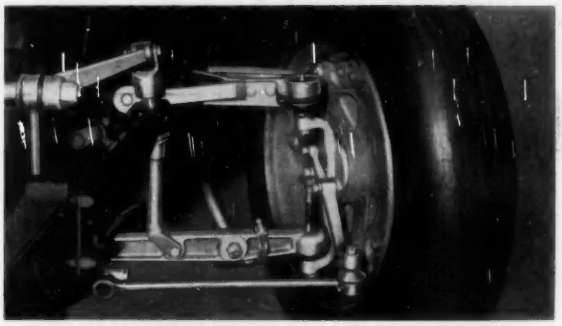


The mechanical brakes would be considered oversize for an ordinary car of the same weight. But the Firebird has so much kinetic energy, at its top speed, brake temperature might become excessive in a single stop. So the split flap air brakes are incorporated.

The flaps are supported from the rear crossmember so that the braking force need not be carried by the body structure. The upper and lower hinge shafts each carry two stub arms to which the flap surfaces are bolted. They are forced to rotate in opposite directions by gear sectors which couple them. Extensions of the lower hinges are coupled by a short universal jointed shaft to assure uniform positioning. They are rotated by a pair of electric screw jack actuators which can open the flaps against the full air drag in 3 sec.

Front Suspension Uses Torsion Bar Spring

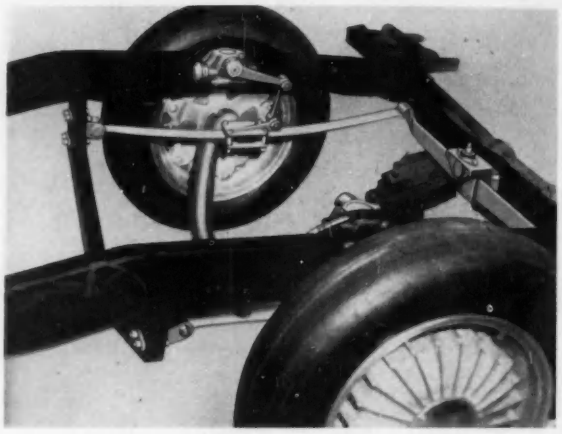


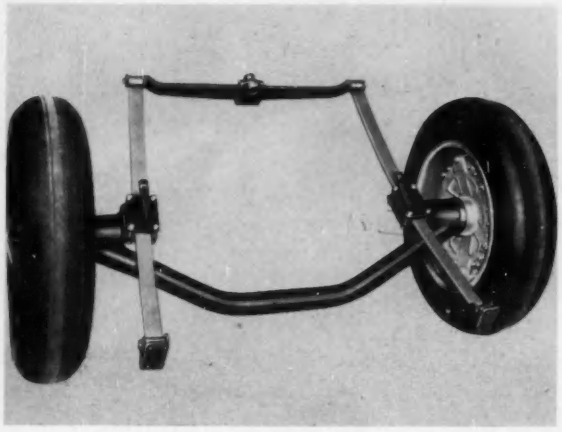


The front suspension, shown schematically at left, is of the double wishbone type with a torsion bar spring and ball joint steering axis. The lower wishbone is horizontal at normal standing height. The upper wishbone is slightly inclined, producing a swing arm of about 110 in. and therefore a rate of camber change of about ½ deg per in. The front roll center is 1.9 in. above ground. The photo above shows the front suspension as seen from ahead.

The raised roll center and camber change action were considered desirable to maintain high cornering power at the front wheels so that the car would not have the slow steering response usually found on parallel action front suspensions.

Rear Suspension Tailored to Car's Geometry





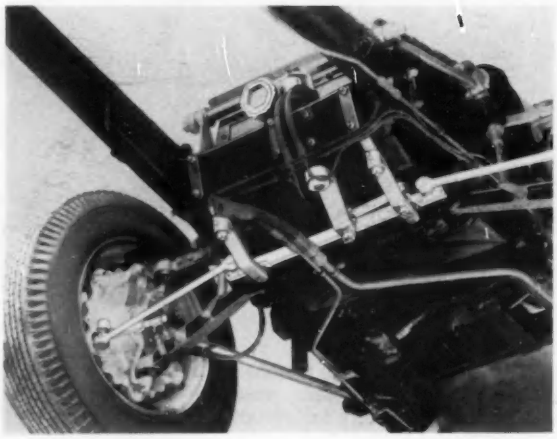
The rear suspension takes form of a De Dion axle with single-leaf longitudinal springs. As shown above left, there is a tubular axle with integral spring seats, single-leaf longitudinal springs connected at the rear to a balance beam and cam-and-lever shock absorbers. The photo at right shows the subassembly of axle, springs, and balance beam.

The balance beam was necessary to assure proper handling in view of the car's unusual geometry. Because the rear springs are located high inside the body, the rear roll center is almost as high as the center of gravity, but the front roll center is low. If front and rear roll rates were about equal, the rear wheels would then carry too much of the overturning couple under lateral acceleration, causing dangerous oversteer.

To avoid this, the front roll stabilizer bar is provided, nearly doubling the front roll rate, and the rear balance beam is used to reduce the rear roll rate to less than 50% of its original value.

Here is why we get this reduction: The balance beam is free to oscillate about a central longitudinal axis, equalizing the loads at the rear ends of the right and left springs. Since it has a cross-section of $\frac{1}{4} \times 2$ in., it is also flexible enough longitudinally to eliminate the need for spring shackles.

Firebird's Steering Mechanism

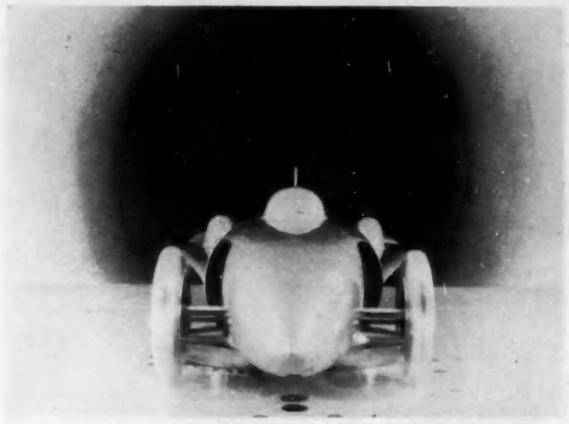


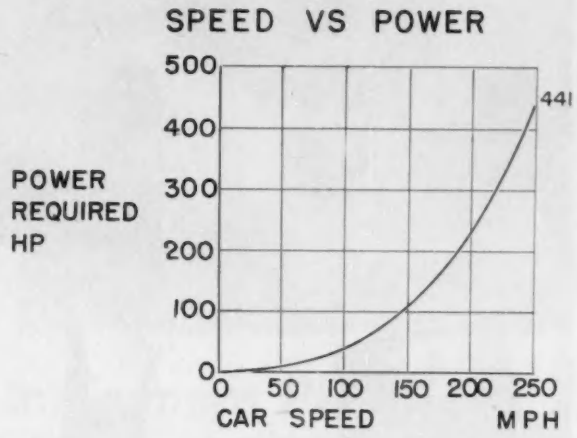
The steering linkage is arranged ahead of the front wheels, as shown in the worm's-eye view above. It is of the parallelogram type, with two idler levers, a connecting link, and tie rods reaching to the steering arms. The whole linkage is in the plane of the lower wishbone and the tie rods are as long as the lower wishbone. The Pitman arm is parallel to the idler levers and connected to one idler by a short link. The geometry is such that there is no Ackerman toe-out in turns. That's because toe-in is required for correct tracking in high-speed driving.

The steering gear is of the recirculating ball type of special construction fitted to this chassis.

(Paper on which this abridgment is based as well as the paper by R. F. McLean, "An Aerodynamic Design in Plastic," are available from SAE Special Publications Department. Price: 35¢ each to members, 60¢ each to nonmembers.)

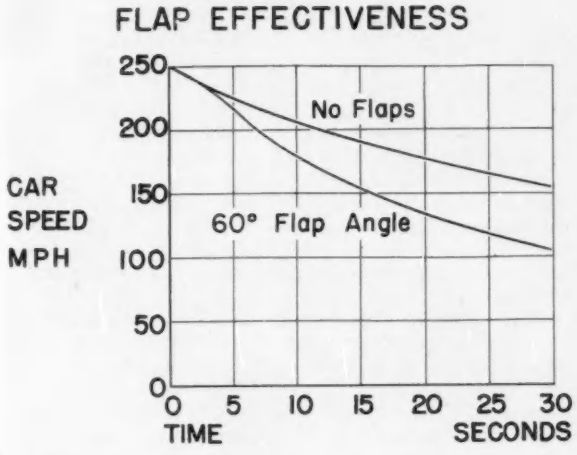
Firebird Body—continued from page 40

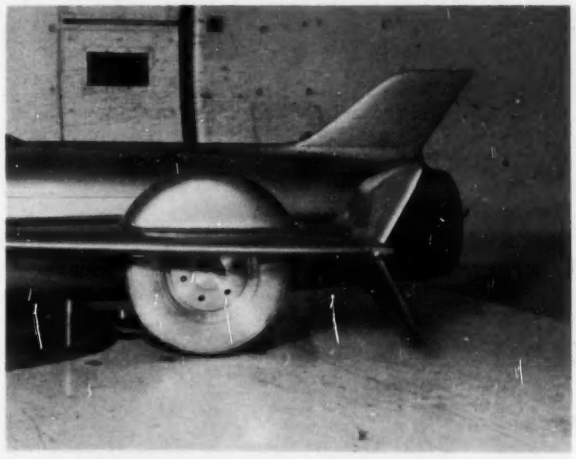




Wind Tunnel Relates Power to Speed

A three-eighths scale model was built of reinforced plastic and tested in the 10-ft diameter wind tunnel at the California Institute of Technology, as shown above, left. The power required in the rear wheel is shown above, right. Note that the car requires only 41 road hp at 100 mph. Between 200 mph (where 230 hp is needed) and 250 mph (where 440 hp is required), the power is almost doubled. Present rated power is 370 hp, corresponding to a speed of 235 mph.



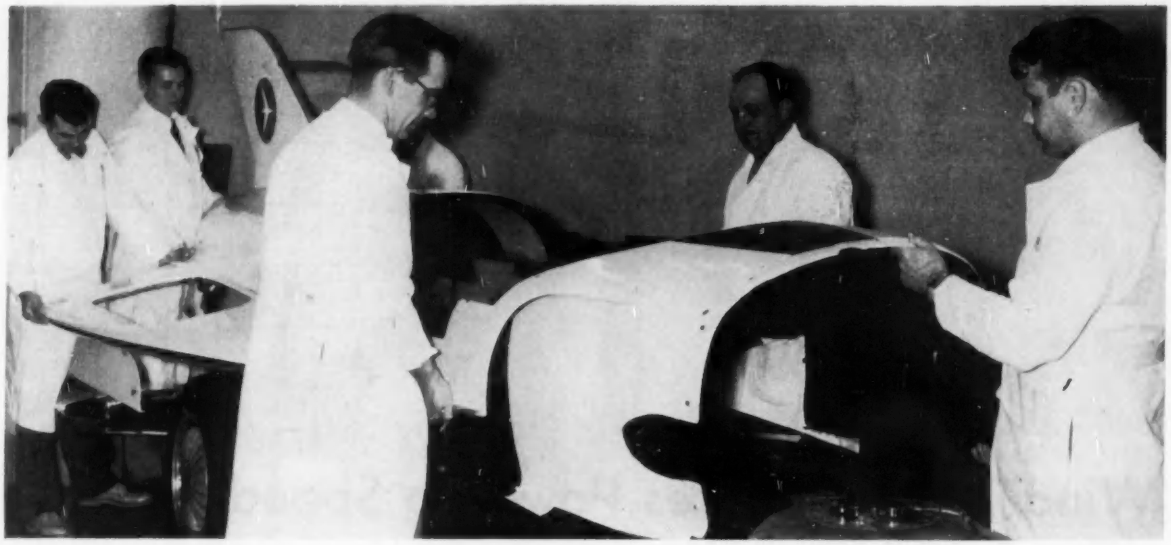


Flaps Furnish Aerodynamic Braking

Deflecting the split flaps fully to 60 deg from horizontal (as demonstrated on the model in the photo above right) adds considerably to car drag at high speeds and produces a braking effect. The chart at left shows calculated speed reduction with time. A 4-sec flap opening time on the actual car is assumed.

Note that the speed is reduced from 250 to 100 mph in 30 sec. The initial deceleration is 0.5g and the distance traveled in this time is about 7360 ft. The upper curve shows the speed decrease without opening the flaps and with power off for the same period of time. Difference in ordinates between the curves represents flap effectiveness.

Firebird Body—continued

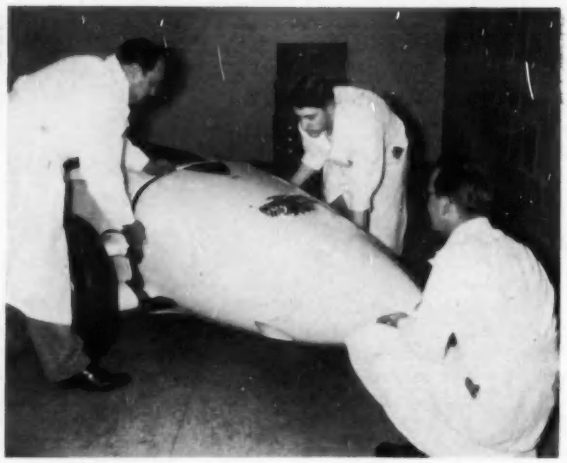


Plastic Shell Comes in Three Parts

The reinforced plastic panels simply wrap around the chassis like an aerodynamically shaped cowling. The main body components are the upper, lower, and nose shells.

Shown above is the upper body shell being placed on the lower one. The nose shell is being positioned in the photo below.

The plastic laminates are made by hand layup. They show a flexural modulus of about 1,200,00 psi. That's a disadvantage compared with steel at 30,000,000 psi or aluminum alloy at 10,000,000 psi. Fortunately, because of reinforced plastic's low specific weight, you can get stiffness by increasing panel thickness without suffering a weight penalty.



The Firebird body panels are about 0.10 in. thick. They compare favorably in overall rigidity with the standard 0.035 gage steel panels usually used.

The shells were formed by hand layup in plaster molds taken from an accurate full-size clay model. The polyester type resin selected shows outstanding resistance to fire and heat degradation.

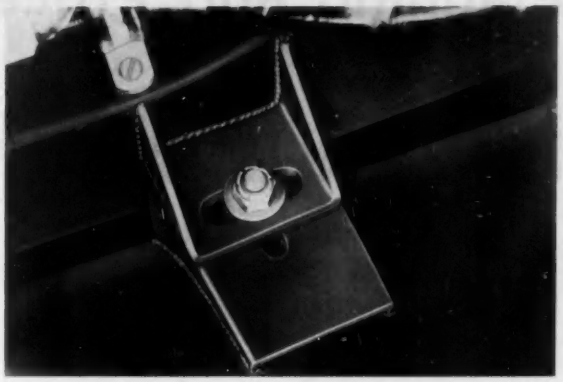
For service accessibility, the body shell was divided into large, easily removed sections. The upper shell includes the horizontal and vertical stabilizers. It fastens to the lower shell with aircraft-type fasteners and it in turn is attached to the steel chassis frame.

Transverse stiffeners were used to help retain the shape of the three primary body components. The stiffeners are heat-treated, formed aluminum alloy channel sections which were bonded in the plastic laminate. The aluminum alloy selected has a temperature expansion coefficient close to that of the plastic-glass laminate. So the danger of bond separation from extreme temperature change is minimized.

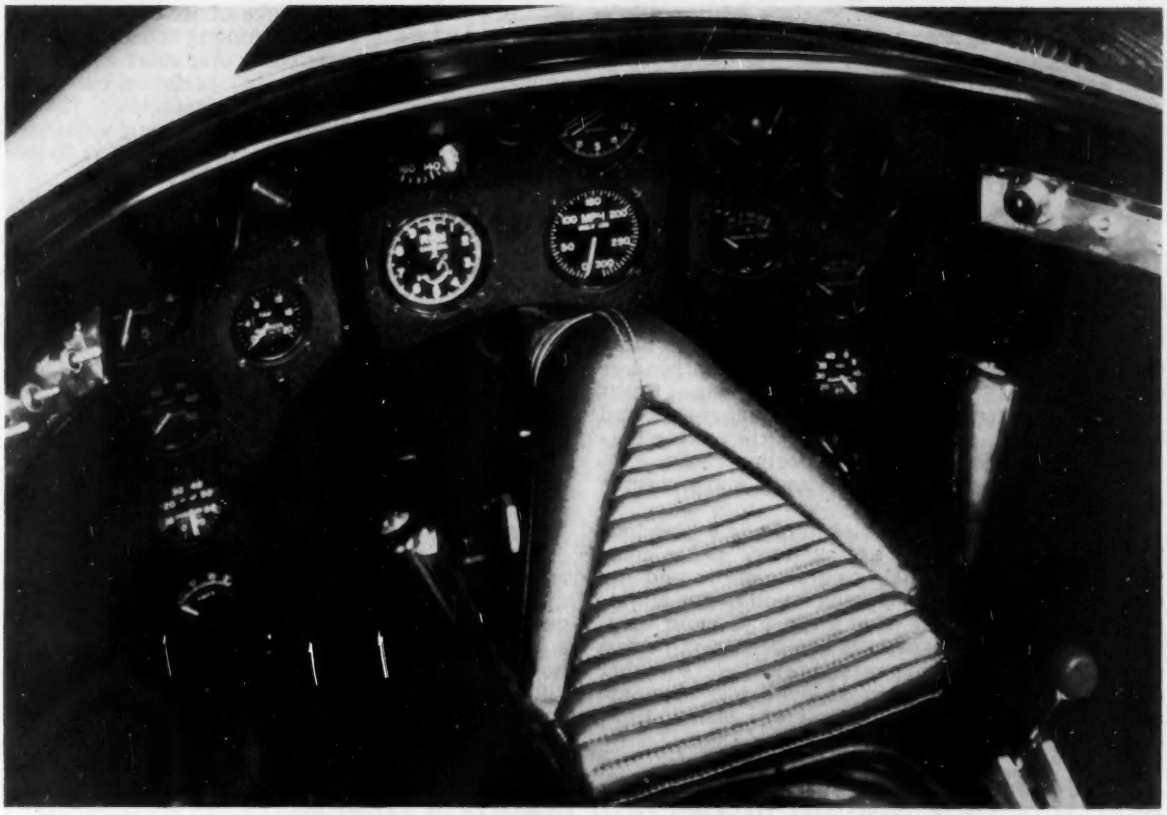
The plastic panels surrounding the engine are protected from the exhaust pipe heat by brightly polished radiation shields of 0.064 gage formed aluminum. The shields are mounted inside the shells. Air spaces on both sides of the shields assist in cooling them by means of flowing air entering the lower shell intakes and exhausting at the tail trim ring. No excessive temperatures have been experienced under actual test conditions.

Special Mount Joins Plastic to Steel

As has been mentioned, the lower shell attaches to the chassis frame. A special body-to-frame mounting was devised because of the difference in linear coefficient of expansion of steel and reinforced plastic. It's shown at right. The mount is welded to the frame and bonded to the body. A slot is provided at the bolted joint to allow the body to move unrestrained in a fore and aft direction. An adjustable plate, which matches serrations in the body shell bracket, allows alignment of the plastic panel transversely.



Firebird Sports Unusual Instrument Panel



The instrument panel has sixteen instruments. They measure temperatures of the gasified nozzle box; tail pipe, engine oil, and transmission oil and pressures of the fuel pump, fuel nozzle, engine oil, and transmission oil. Other instruments are the gasifier tachometer; power turbine tachometer calibrated in vehicle miles per hour; air speed indicator; direction compass; clock; fuel level indicator; volt-ammeter; and a flap position indicator.

The instruments are grouped and color coded for easy reading. Warning lights indicate over-temperature conditions, single-burner starts, and transmission oil pressure difficulties.

The special steering control used for a straight-away running are seen above. Flap control switches are located at the top of each handgrip, the arrow indicating flap travel direction. For closed course running, involving cornering, a circular steering wheel may be used in place of the handgrip arrangement.

Planning and Processing

Lower Cost Inspection for

THE lower inspection costs and better products that quality control men want may come from a multipronged attack on inspection problems.

Closer work by prime contractors with vendors is already moving many plants toward these twin goals. Growing management care for quality control needs is helping, too. Inspection costs are being gaged as a ratio with production costs. Better pre-planning of inspection processes and tooling is being encouraged as well as permitted. More interchange is taking place in pre-production stages between inspection-planners and engineering, production, and purchasing.

And better application to inspection of quality control's expanded knowledge of its own processes is making its mark as well. Among the areas where experience-knowledge is being ever more accurately applied, for instance, are: (a) decisions on where sampling is better than 100% inspection; (b) on where time standards are feasible or impossible for inspection work; (c) where "in-process" is better than "final" inspecting—or vice versa.

Better Touch with Vendors Cuts Inspection Costs—

Some of the most effective progress is coming from the prime contractor who works ever more closely with his vendors. He is giving his vendors more information—and giving it sooner. He is working with vendors on ultrasonic, magnetic, and other processes. Together the two are getting better parts with less receiving inspection cost.

This "working together" reflects in many specific instances.

Ultrasonic inspection, for example, is a new tool. So far, its requirements are sketchy. Some companies have written their own standards and arranged for inspection at the source on heavy aluminum ingots, extrusions, spar caps, and hand forgings. Where such inspection has been arranged, a process standard has been written. . . . In other cases, magnetic inspection of bolts has been arranged outside the prime contractor's plant. Here, this arrangement has been worked out with the purchasing department.

Full liaison between quality control and purchasing usually affects favorably the quality-cost objective. More such exchange of information can bring better control of purchase orders written by subcontractors, for one thing. And it can better enable prime contractors to spend money for inspection fixtures to reduce inspection costs—both in his own and the vendor's plant.

Receiving inspection, of course, can be caught rather badly when an expanded program suddenly ups the ratio of subcontract material. Only adequate prior planning can protect it on costs in such a case. Until standardization is more complete, however, prime contractors will continue to have difficulty immediately coordinating various subcontractors' "writeups" on entirely new processes.

Management Seeing Inspection Needs Better—

The question of what is a high receiving inspection cost remains moot.

Management is likely to opine: "Whatever the cost is, it's too much." But it's pretty well recognized that:

(a) quality cannot be compromised, and
(b) production flow must be maintained.

The trick is to spot when inefficiencies in receiving inspection can no longer be tolerated to keep up the production flow. Cost of a product is far more related to production cost than to inspection cost. . . . And receiving inspection cost depends also on how much vendor quality control has been applied to a given part.

The relation of inspection to production costs is, many think, the best way for management to gage inspection costs. But no way has been suggested of

Better Quality Control

R. H. Hopkins, Northrop Aircraft, Inc.

Based on excerpts from secretary's report of panel on Quality Control held as part of the 1953 SAE Aircraft Production Forum, Los Angeles, Sept. 29, 1953.

relating inspection costs to dollar-value of material purchased. "There probably is an economic ratio", one executive believes, "which may be learned over a period of time—and then watched consistently to see if costs are changing."

Planning inspection and its tools into the operational blood-stream before production starts is getting more common. It's being recognized as being good management procedure.

Sometimes, of course, it's easier to pre-plan product serviceability checks than in others. To pre-plan a complete airplane line before the production line is established, for instance, would be next to impossible. But, always the aim is to find the earliest point at which inspection pre-planning can begin effectively.

Usually, a drawing made by engineering is the first step in a manufacturing process. Then tool planning takes the drawing and decides what production tools will be needed. Next, production planning breaks that analysis down further. It decides how and where to build the piece.

There, many think, inspection should begin to do *its* pre-planning. It should try to determine—right then—just how the inspection is to be done . . . before the job gets into the shop.

In one company, a group called "quality analysts" does inspection planning. It takes the production engineer's production plan and notes on it the inspection points; sometimes also the inspection tools required. Then it prepares written instructions for use in the shop, for the various inspection operations.

Establishment of standard times for inspection processes seems currently to be in the experimental stage. No complete time-study programs have been installed as such for inspection operations, but some may be tried soon.

A good controlled audit system to go with standard-hours setups seems to be essential. Without it, one expert said frankly, "the standard-hours procedure will fall flat on its face. . . . And it can cause production bottlenecks, if improperly planned.

The few airplane companies which have set up any time standards for inspection have set them rather on "invoices" than on individual parts. The result is expressed in so many invoices per day per inspector. The individual part basis would be impractical where the items received from day to day vary so greatly, it is explained, that each day's group is entirely different. "It's like a grab bag."

Lack of time standards, however, does not necessarily mean that pre-planning is inadequate. The pre-planning can, and usually does, involve use of other standards—which do help toward better quality and lower cost inspection.

Some companies have studied in advance of production the cost of special inspections to take place after the part is produced. Such advance study usually is undertaken in connection with complicated fixtures.

For failure to get adequate inspection tools, quality control men are inclined to blame themselves rather than management. Inspection tool requirements, they say, should be planned and budgeted for at the same time as are production tools. That this is rarely done, quality control men think, is because they have not convinced management of the

The panel of quality control experts who led the discussion on which the article is based consisted of:

Panel Leader:

R. S. CATLIN, Director, Quality Control, Northrop Aircraft, Inc., Hawthorne

Panel Co-Leader:

G. A. COVINGTON, Manager, Quality Control, Consolidated Vultee Aircraft Corp., San Diego

Secretary:

R. H. HOPKINS, Statistical Quality Control, Northrop Aircraft, Inc., Hawthorne

Panel Members:

D. A. HILL, Director, Quality Control, Hughes Aircraft Co., Culver City

W. C. HITT, Assistant Chief, Quality Control, Douglas Aircraft Co., Inc., Santa Monica

R. F. MARTIN, Chief Inspector, North American Aviation, Inc., Los Angeles

E. S. BARNHART, Quality Control Manager, Solar Aircraft Co., San Diego

The secretary's report, of which this article is a brief abridgment, contains a wealth of specific-experience data contributed by members of the panel and other experts. It runs to 30 single-spaced typewritten pages and is available as part of SP-304, along with reports of other panels at this 1953 Aircraft Production Forum (LA). SP-304 is available from SAE Special Publications Department, 29 West 39th St., New York 18, N. Y., at $2.00 to members; $4.00 to nonmembers.

need for quality control inspection tools. "Too often," one says, "we find ourselves—after production has started and time for inspection arrived—having no means to inspect it."

"We should show management that we need tools," says another. "We should get provision for them made along with production tooling. We must get our needs recognized before all other tools are provided and the money has run out."

In every inspection job, of course, the process has to aim at the best possible *practical* result. That is usually less than the ideal. The materials review board which some companies have is probably evidence that something less than the ideal in inspection is practical. Such a board's function is to review things that don't manage to come out just as the engineer put it on the blueprint.

Few believe that it is possible to write a specification to actually describe all possible minor variations that could occur.

A generally accepted working principle seems to be: "Accept something short of perfection—but stay within the specification."

"The blueprint is just a guide. All reference specifications are not included in it," is the way one quality control man puts it. "These specifications have to be analyzed as each affects the parts or assemblies. Quality control can help—and be helped—in making such analyses. . . . Sure, we are confused, the same as production people are confused. But, at least, we can start from there to learn something."

In such areas as these, management seems increasingly to recognize, quality control men can often help other departments. They may, for instance, aid production in review of its own tool planning and tool design. They may contribute an understanding of what isn't on the blueprint—as well as of what is.

QC Techniques Ever Better Applied—

Quality control men continue to explore how better to apply growing knowledge of their own techniques. They continue to debate the desirability of sampling as opposed to 100% inspection in individual cases; the chances of applying time standards to inspection work; and the limitations of both "in-process" and "final" inspection procedures.

Possibilities of sampling as opposed to 100% inspection, of course, have a strong bearing on the quality-cost aim. Increased and better instrumentation is involved, too.

Some, for example, believe sampling inspection actually can be better than 100% inspection—provided it is *correct* sampling inspection. But sampling does involve a calculated risk. "If you can't afford a risk," according to one expert, "you can't afford sampling inspection."

Several ideas are being suggested which might permit sampling of such items as electronic equipment—which usually gets at least 100% inspection.

Suppose, for example, a vendor has a satisfactory quality record with a prime contractor. Then, it has been suggested, receiving inspection might go to sampling without knowledge of the vendor's process control. But greater assurance accrues to both contractor and vendor, it is added, when they can agree exactly on characteristics to be controlled.

When specific component characteristics are sub-

ject to cumulative error, agreement must be reached as to centering about a specific average.

"If we spend a lot of money in functional testing articles 100%," one leader summarized, "we have no assurance that when a part of a piece of electronic equipment is used in a later installation, it will function. It's better to establish a sampling program for testing electronic equipment, because isolating failures after installation costs too much. . . . (There is a wide open field for development of electronic equipment that will stay in usable condition while in storage.)

A good many quality control men feel that development of inspection equipment isn't keeping pace with that of production equipment. "We can't seem to get fast acting equipment; equipment that will function in the time we have allotted to it," is one complaint. But another thinks inspection folks want things too easy. "We want to point a pointer at a part and have a hand come up and tell us whether it's a good or a bad part. . . . This type of inspection will not come easy!"

"In-process" inspection was pointed up as the only economic means of inspection in many instances. But it was also noted that its primary purpose probably is to protect the manufacturer, while the "final" type of inspection is more a protection of the customer. It seems agreed, too, that "in-process" inspection can be carried to silly lengths. A small, inexpensive production unit, for instance, does not rate any "in-process" inspection. It might be cheaper to throw the defective units away than to inspect "in-process."

"In-process" inspection is a very good thing," one expert concluded, "but you really ought to call your shots pretty carefully."

And In Conclusion—

Generally, it was agreed that more new methods and new techniques still are needed, that inspection tooling should be developed as the piece is designed; that closer coordination between quality control, engineering, tooling, and vendors is necessary . . . and that, if progress goes forward in all these areas, a more reliable product is almost certain to result in the future.

New Body Paints . . .

. . . are on the way. Great strides made with epoxy resins and modified silicones. Advent of plastic bodies introduces peculiar paint problems.

Based on paper by **A. J. LaPointe,** Ford Motor Co.

NEW film forming materials may gradually supplement or even supplant the conventional alkyd amine resin vehicles now used so universally in automotive enamels. Progress is being made with the epoxy resins and modified silicones, but the technology of these materials is still young compared to that of present alkyds and the aldehyde amine types.

The glass fiber-polyester resin bodies now being launched present their own peculiar paint problems. Their structural and fabricational characteristics have dominated the selection of compositions, but when the situation is more nearly resolved, more uniform plastics will result and their dimensional stability will be better understood so that painting can be properly standardized.

The need for lower temperature curing enamels and undercoats for use on plastic bodies will certainly be met by new and improved formulations which will fit required schedules. No doubt curing agents, similar to the diisocyanates, will be found that will aid in solving this problem. There is also the possibility of working out a combination spray gun that applies the paint and the catalyst simultaneously in the correct ratio. Some of the more prominent spray gun manufacturers have made guns for proportioning the required catalyst with epoxy type enamels.

Undoubtedly plastic bodies will be made of more solvent resistant resin binders, at least superficially. But the problem of solvent swelling might also be solved by the formulation of some very resistant barrier coat or sealer. Some of the currently annoying patterns that show up with plastic bodies now being developed, could be eliminated if the swelling of both the substrate and the surfacer could be reduced. (Paper "Automotive Enamels" was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 2, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Based on Discussion

Question: Is enamel more resistant to scratches than lacquer?

Answer: Scratch resistance of enamels and lacquers is approximately the same under comparable conditions, such as age of the films, etc.

Engine Installations

Why Buried Installations Aren't As Good as Underslung Nacelles

—B. T. Salmon,
Consolidated Vultee Aircraft Corp.

BURIED-in-wing installations of jet engines result in slower, less efficient transports than do underslung nacelles.

Burying the engine may appear to clean up the aerodynamics of the airplane. But actually it is likely to cut cruising speed 50 to 75 mph. That's because it is necessary to increase wing thickness to accommodate the engines and the landing gear.

With thicker wings, cruising speed must be lower in order not to exceed the minimum-drag-rise Mach number.

Buried-Engine Plane is Heavier

Burying jets does give lower design air loads. Aspect ratio is increased, and less power is required. All this requires less fuel and tends to reduce gross weight. But these reductions are somewhat offset by increased wing weight incurred by cutting up the wing structure to accommodate the powerplants.

Drag coefficient is about the same for both buried installations and nacelles. But the longer, more obstructed inlet ducts leading to the buried jets dissipate more of the ram energy of the entering air.

The underslung nacelle housing both the jet engine and the main landing gear results in a faster airplane. Besides, it leaves an unbroken wing structure with room for all of the fuel outboard of the fuselage, which buried installations almost surely can't do.

The underslung nacelle offers good access to the engines for servicing, inspection, and maintenance. There's no need for stressed access doors, as with buried installations.

With the nacelle configuration, it is relatively easy to protect the primary structure against engine fire since the engine can be located entirely behind the rear spar of the wing. This location is particularly advantageous as regards location of the jet noise cone relative to the cabin.

Also, when the engine is surrounded by heavily loaded wing structure, much heavier shrouds, shields, and insulation are required for protection against the fire hazard.

Despite the British

Buried-engine jet transports can be built—the British have housed the engines within the wings of their Comet and a number of bombers as well. But we think buried installations are not as advantageous as underslung nacelles, all factors considered.

for Jet Transports

What Operators Require . . .

—W. W. Davies and H. N. Taylor

United Air Lines, Inc.

WE don't presume to say what the optimum location or type of installation is for jet engines. That we'll leave up to the designers.

What we do insist upon is that the configuration insure:

- Safety,
- Passenger comfort, and
- Service reliability.

Here are some of the features we'll look for in any jet transport we buy:

Fire Safety—The installation must be as safe as possible from the standpoint of fire.

The engine housing must prevent fire from spreading to the rest of the airplane if engine fire does occur.

Drainage—To lessen the chance of engine fire, there must be adequate drainage to dispose of possible leakage of flammable fluids.

Fuel Location—Fuel, whatever type it is, must be carried in a part of the plane where it will offer the minimum hazard at all times.

. . . Pod Mountings Offer

—G. S. Schairer

Boeing Airplane Co.

WE favor pod mountings primarily for their safety and maintenance characteristics. Such factors as these, rather than performance, will be the basis for the final choice, we believe.

(Only by comparing completed actual airplanes can a fair comparison of performance be made. However, all the comparisons we've seen show negligible differences in performance capabilities for different types of installations.)

Here's why we think pods are the best answer to operators' requirements:

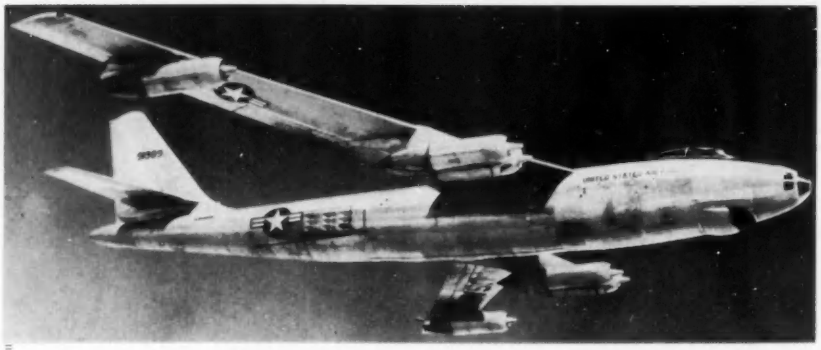
With pod-mounted powerplants, the free air space between pod and wing practically guarantees that any powerplant fire will not seriously damage primary structure. The strut joining pod and wing can easily be partitioned and sealed against fire.

Fuel, oil, and vapors emitted from an engine can readily drain from a pod without any danger that they'll collect elsewhere in the airplane.

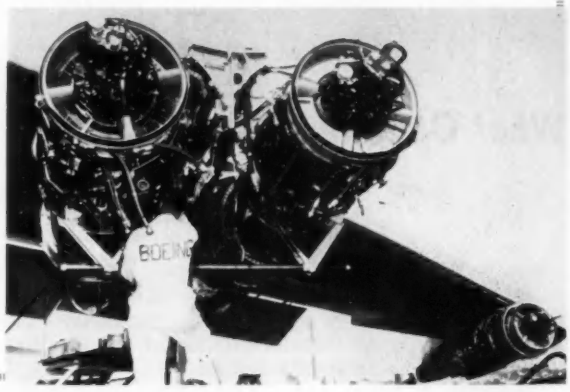
Pod-mounted engines, being external to the wing, take up none of the wing space. Fuel may therefore be placed as far out on the wing—that is, as far away from passengers—as fuel volume permits.

Buried installations take up so much wing volume that some of the fuel might have to be carried within the fuselage.

Jets suspended in pods from B-47 wings . .



. . . are quickly uncowled for complete access.



USAF design specs for the B-47 stipulate a maximum of 30 min per engine change. Boeing's crew proved compliance by changing an outboard engine in 19 min and 45 sec and a twin-mounted inboard engine in 25 min and 15 sec, it was announced on February 25. (It took 15 hours and four men to change an engine on the B-29.)

What Operators Require . . .

Isolation—Proximity must not encourage contagion of jet engine failure. If some of the parts of one "whirling dervish" happen to come loose, we don't want them to mangle an adjacent engine.

Accessibility—Jet engines must be readily accessible for maintenance and servicing.

Engine replacement must be easy—but that alone isn't enough. With spare jet power packages costing $250,000, we can't afford to replace an engine with an unserviceable component and repair or renew the component later. We have to be able to get at the component itself.

Accessibility must be of such a degree that maintenance can be accomplished fast. We can't afford to have these expensive aircraft on the apron. They must be in the air generating revenue.

. . . Pod Mountings Offer

continued from page 54

With separate pods, a failed engine is completely isolated from other engines. It is hard to see how such isolation can be provided when engines are mounted inside a common structure, as with buried installations.

Pod mountings implement the philosophy that all possible engine maintenance be accomplished without removing the engine from the airplane. It's important not only to be able to maintain the engine on the airplane when something goes wrong. It's important to be able to conduct thorough inspection and preventive maintenance.

Pod mountings give plenty of accessible room for accessories, also.

The same accessibility features that make an airplane easier to maintain can be expected to make it cheaper to manufacture also.

What Operators Require . . .

continued

Inlet Protection—Engines should be located where they won't be likely to collect blowing debris and other foreign objects. Jet engines have delicate appetites. We'd rather have engines located out of the way of unpalatable morsels than be burdened with complicated closures.

Noise Protection—The engines must be so located that the cone of the jet exhaust and the shock waves from it are not directed against the fuselage in the vicinity of the passenger compartment.

Freedom from Exhaust Deposits—Engines should be placed so that their exhaust does not leave corrosive deposits on airplane structure. We have to wash the whole airplane frequently to control corrosion. But we don't relish extra, complicated washing procedures for the exhaust track area.

THIS round-up of opinion on housings for turbojet engines for transport aircraft is based on the papers:

High Speed Transport Turbojet Installation Considerations
by B. T. Salmon
Consolidated Vultee Aircraft Corp.

Jet Engines from the Operators' Viewpoint
by W. W. Davies and H. N. Taylor
United Air Lines

Why Pod Mounted Engines Make Sense
by George S. Schairer
Boeing Airplane Co.

The papers were presented at the SAE National Aeronautic Meeting in New York in April, 1953. They are available in full in multilithographed form from the SAE Special Publications Department. Price is 35¢ each copy to members, 60¢ each copy to nonmembers.

. . . Pod Mountings Offer

continued

Pod mountings ought to be as safe as any in regard to debris. We feel that the intake problem is related mostly to articles already in the air, such as paper blown by the wind or stones or slush thrown up by the nose wheel.

A recent test showed that a jet engine would pick up a candy wrapper from a large flat board only when the board was within 18 in. of the engine.

Pod mountings permit great reduction in noise level inside the passenger compartment as compared to engine housings close to the body.

Noise from a jet engine is radiated forward from the inlet and in a cone of about 90 deg whose apex is at the centerline of the jet nozzle. Doubling the distance between an observer and the noise source reduces the sound as measured in decibels by six. Pods permit the greatest distances between passengers and jets.

Pod engine installations permit arrangements such that jet blast doesn't strike airplane structure —nor subject it to serious heat or vibration. With other types of installations, even pressurized portions of the airplane are sufficiently close to jet blast to be markedly affected.

Pods have an additional advantage from the designer's viewpoint: Pod-mounted engines can be used to boost flutter frequencies high enough so that flutter won't occur. Our studies of the effect of engine location on flutter speed show that the optimum engine location is 50–70% out on the wing. The studies show also that the center of gravity of the engine package should be near or ahead of the local wing leading edge. These considerations point toward use of pods.

Properly mounted pods have a favorable effect on longitudinal and lateral stability and control characteristics near stall. This is particularly important with swept back wings, which by themselves have poor stability near stall. Pods benefit swept wings more than fences or slats do.

Even with pods mounted far out on the wings, engine-out performance is not unsatisfactory in cruise. (The problem of asymmetrical thrust during engine-out performance is one of the objections buried-engine proponents have raised against pod installations.) Unlike propellered aircraft, jet aircraft do not experience a rolling moment immediately after engine failure. That's because there's no propeller slipstream flowing over a jet wing, anyway. The jet plane doesn't encounter rolling moment until it begins to yaw after engine failure. However, the asymmetrical thrust is significant when an engine fails during climb.

Cessna

THE CESSNA L-19A, the production version of the L-19, is powered by a Continental O-470 piston engine rated at 213 hp. This U.S. Army liaison plane will take off over a 50-ft-high obstacle in 560 ft and will land over a 50-ft obstacle in 600 ft. Rate of climb at sea level is 1130 fpm. Service ceiling is 22,900 ft. On 20 gal of fuel it can fly for 3.1 hr. It will cruise at 90 mph at 5000 ft with 29% power. The Army has more than 1500 L-19A's.

IT'S possible to use current turboprops in light planes if you want to. But for the same performance as piston engines give, turbines require much more fuel.

This is the conclusion Cessna Aircraft reached after experimenting with both the Boeing 502-8 and the Continental Artouste turboprop engines in the Cessna L-19 liaison plane. Purpose was to discover for the Army what the performance and the problems would be.

The project proved that performance is good —but not good enough to justify the turbine's high specific fuel consumption for most light-plane missions. For given range, turbines require much more fuel tank capacity. Also they take more total energy input to start.

The only justification for light-plane use of small turbines, in their present state of development, would seem to be for high-altitude, high-cruising-speed missions.

Actual performance figures on the turbine-powered L-19's have not been released by the military services. But it can be said that the turbines, once started, gave adequate power throughout the airplane speed range with no engine overspeed or stall problems.

The turbine planes require slightly different piloting techniques. But both experienced and inexperienced pilots adjusted to the differences readily.

The starting procedure for the XL-19's Boeing turboprop is quite simple. As soon as the starter brings the engine to 4000 rpm, the pilot turns on the fuel. A muffled roar usually marks the initiation of combustion, making it apparent to the pilot. He keeps the starter on until the turbine comes up to minimum idling speed.

During taxiing, thrust change with throttle movement is slow but not objectionable. In take-off and climb, acceleration is rapid and uniform as long as the pilot controls the throttle properly.

Level flight presents no special problems, and in the landing approach, the XL-19B's glide path is normal. Deceleration on the ground is slower, however, since the turbine engine at its high idling speed of 1100 rpm gives more thrust than an idling piston engine does.

The XL-19C, powered by the Continental Artouste, operates similarly to the XL-19B. The XL-19C is a little harder to control on the ground because its engine at minimum idling speed gives about 100 lb of thrust. But pilots soon learn to compensate for this with moderate use of brakes.

Flame-out or sudden throttling of the Artouste at cruising speed decelerates the XL-19C sharply, but not dangerously.

The XL-19C engine can be restarted in the air by diving to windmill the propeller. The spinning propeller brings the compressor, which is connected to the propeller through shafting and gears, to starting speed. The XL-19B engine can't be restarted in flight this way because the propeller is not mechanically connected with its compressor.

Both of the engines require a greater total starting effort than the conventional reciprocating engine. The starter must bring the compressor up to its minimum speed for supplying enough air to the combustion chamber to start a rapid burning of fuel for acceleration to minimum idling speed. During this period, the starter is constantly engaged and is aiding in accelerating the turbine to its minimum idling speed.

A heavier starting motor and a larger battery are normally required for the turbines, since the starting time is longer and the current requirement is higher. An 11-amp-hr battery gave one turbine start in the air or on the ground. Cessna therefore used an auxiliary battery cart to avoid the additional weight penalty of a larger 24-v battery.

One of the advantages of the turbine is its high output at altitude. The engine will continue to

Tries Two Turboprops in the L-19 Liaison Plane

J. H. Gerteis, Chief Engineer for Commercial Aircraft, Cessna Aircraft Co.

Based on paper "Light Aircraft Turbo-Propeller Installations" presented at the SAE Annual Meeting, Detroit, Jan. 14, 1954. Paper is available in full in muitilithographed form from SAE Special Publications Division at 35¢ to members, 60¢ to nonmembers.

operate at high altitude with some increase in tailpipe temperature and a slight loss of power.

Although the Boeing engine was not specifically designed for high-altitude performance, Bill Thompson, Cessna's chief test pilot, flew the XL-19B to 37,500 ft one afternoon to set a record for airplanes of this weight. In climb at this altitude, the engine flamed out when the throttle was changed to reduce the too-high tailpipe temperature. Since the battery was removed to reduce weight to a minimum, it was impossible to restart the engine with the Boeing free-turbine arrangement. But Bill came down and made a "dead stick" landing without mishap.

The large volume of exhaust gas coming from a turbine engine was hard to keep out of the cockpit, especially with the XL-19B window open. In the XL-19C, the hot exhaust gas along the belly of the airplane heated the aluminum skin to 300 F in a few spots. Scavenging action of additional cool air in the region of the landing gear might be required to reduce this temperature.

About 20% loss in strength was expected after prolonged exposure of the 24ST skin to this high temperature. Test specimens of 24ST were cut from one section of this belly skin exposed to 300 F air for about 30 hr. The actual reduction in physical properties was about 5%. Apparently the skin did not become hot enough to reduce the strength of the aluminum markedly, even though the surface temperature was high.

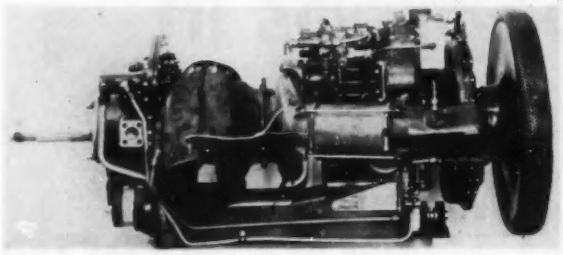
No change in noise level was noticed in flight since the propeller was turning at about the same speed as with the reciprocating engine. On the ground, however, observers noted that the noise was reduced.

Range and endurance still remain one of the problems for turbine-powered light aircraft. The high fuel consumption of these engines makes the reciprocating engine clearly superior in this field. Part-throttle operation at reduced speed is especially advantageous for the airplane and disadvantageous for the turbine engine.

The turbine can, however, simplify operation and maintenance of the small airplane. The use of cheaper fuels and the overall simplicity of the turboprop arrangement offer much promise for future designs.

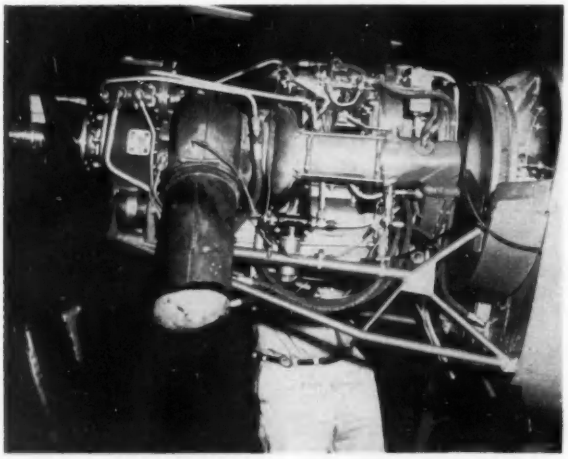
Descriptions of the two turboprop installations in the L-19 appear on the next two pages.

The Boeing Model 502-8 Installed in the XL-19B–



The Boeing Airplane Company's 267-lb Model 502-8 has a normal rating of 175 hp at 36,000 rpm and 228 lb fuel per hr and a take-off rating of 210 hp at 37,700 rpm and 252 lb fuel per hr.

Air enters the screened air intake silencer and proceeds to the compressor, which is rigidly connected to the first-stage turbine. Compressed air picks up heat energy in the two burner tubes at the sides of the engine. Then it gives up the energy to the first-stage turbine, which drives the compressor, and to the second-stage turbine, which drives the propeller through a gearbox.



The exhaust gases escape through the two downward and outward pointing tubes at the front of the engine. They add nothing to the thrust.

Exhaust gas flow is greater than with piston engines, and gas tends to enter the cabin, particularly if the window is open.

The power turbine drives the propeller through a 10.897 to 1 reduction gearbox.

The engine idles at 14,000 rpm without flameout. Maximum speed is 37,500 rpm.

The Model 502-powered L-19 first flew on Nov. 5, 1952. (Before this time, the powerplant and its relatives had been installed experimentally in trucks and boats. Since, a version of the powerplant has been tried out for helicopter service.)

Since the Model 502-8 is lighter than the piston engine for which the L-19 was designed, the turbine engine is mounted 8¾ in. farther forward to maintain proper balance. This gives a long nose with slightly reduced visibility.

Because the propeller has no mechanical connection with the compressor, the airplane operates satisfactorily with a fixed-pitch propeller.

Response to throttle movement from idle to full-power position is satisfactory.

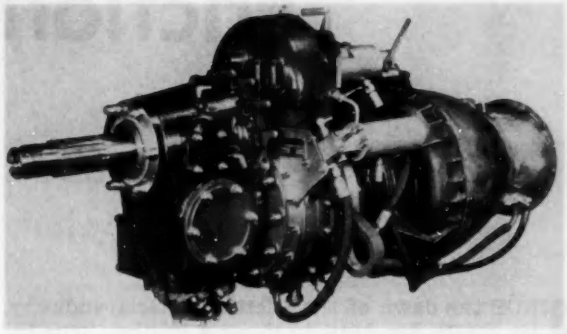
An acceleration limiter in the fuel-metering system prevents overloading of the engine by sudden throttle movement.

—The Continental Artouste Installed In the XL-19C

The Artouste engine was designed by the Turbomecca organization in France and licensed to Continental Aviation and Engineering Corp. It is one of a family of small gas turbine engines designed by Turbomecca.

The Artouste installed in the XL-19C had a normal rating of 265 hp and a take-off rating of 280 hp. It first flew in the XL-19C last September.

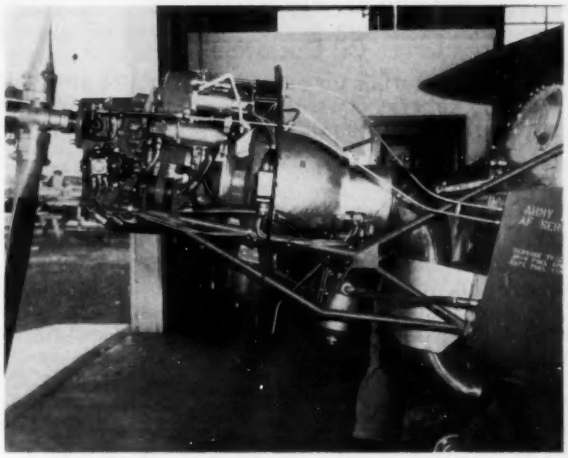
The Artouste has a single-stage compressor and a single turbine designed to operate at 35,000 rpm. The turbine drives the propeller through a Continental-designed gearbox which reduces shaft speed from 6000 to 2200 rpm.



Intake air enters the screened ring just behind the nose case. It is compressed, burned, discharged against the turbine wheel, and exhausted out the rear of the engine. The engine is designed so that the exhaust could yield 40 lb jet thrust if it escaped directly as from a wing installation. But this energy is lost in the XL-19C because of curves in the outlet.

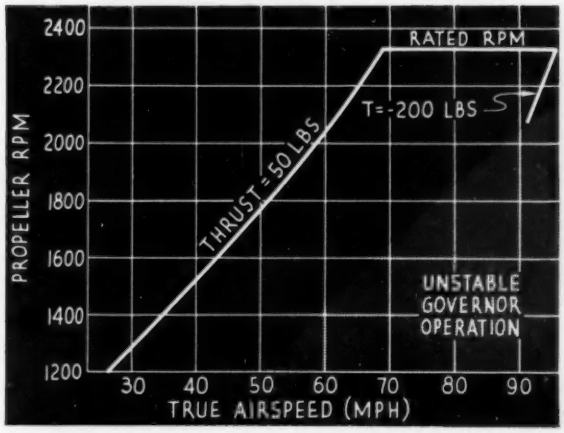
In the XL-19C, the propeller is installed 14 in. forward of its position in the piston-engine-powered version to give room for the special tailpipe.

Most outstanding characteristic of the XL-19C is its high cruising speed resulting from higher power and a constant-speed propeller. Range of the airplane was improved by carrying 84 gal instead of the usual 40 gal.



Because the propeller and compressor are mechanically connected in the XL-19C's Artouste engine, the airplane is operated with a constant-speed propeller instead of a fixed-pitch propeller. However, analysis showed that there is no need for special devices to change the low-pitch stop, decouple engine and propeller, or feather.

The chart shows propeller governor operating limits with the low-pitch stop set at 4 deg. As the throttle lever is moved to reduce thrust with the governor set for high rpm, the governor calls for higher speed and lower pitch. Thrust drops and the airplane slows down. If the throttle is again moved to cut thrust, the system will stay in the stable range. If not, no serious trouble results, anyway, although the glide path is affected.



Friction Materials Are

SINCE the dawn of the friction material industry, its dream has been to make a friction material with an indestructible, inorganic bond that also has suitable friction properties. Although this dream has not yet been realized, many improvements are helping to meet the greater and greater demands for both wet and dry applications.

Oil Operation

Friction materials for oil operation can be grouped into four general classifications. Arranged in decreasing order of popularity, they are:

- Resilient.
- Semimetallic.
- Rigid molded.
- Fully sintered metallic.

Resilient Material—Resilient types contain a binder and, principally: cork, cellulose, and asbestos. The most popular resilient material consists of a dual-faced assembly, with alternately opposed nesting rings of cork and cellulose.

All resilient materials have low specific gravity, are somewhat porous, and have low tensile strength. The coefficient of friction is high, covering 0.13–0.075.

Natural cork—that is, cork as it is stripped from the tree, without any artificial binder—has the highest coefficient (0.13). If it were available in commercial quantities, it would undoubtedly find wide application.

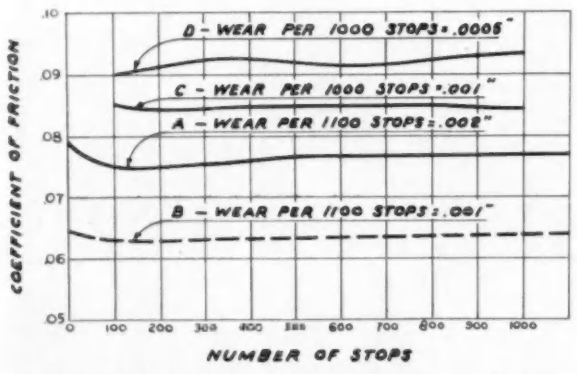


Fig. 1—Properties of friction materials in oil operation—resilient type

Resilient materials in general have good engagement characteristics by virtue of their compressibility, which causes slow buildup of applied pressure. Their natural dampening characteristics tend to prevent chatter—and they are cheaper than any of the other materials.

One of their limitations is that the major portion of their composition is combustible organic. Cork and cellulose materials char to destruction at about 400 F. This imposes a relatively low-temperature ceiling on their successful operation.

Fig. 1 also shows another limiting factor. Note that friction drops off progressively from the beginning to the end of the test. (Although there is a definite drop-off in friction with use, it should be noted that this test was an accelerated one for the intended service. Thus, it tends to exaggerate greatly the frictional drop-off.)

Wear—or apparent wear—of resilients is very high compared to other types. (The term "apparent wear" is used because often what appears to be wear is, in part, the effect of compression.)

Woven asbestos friction material is also a resilient, consisting mainly of asbestos and binder. It is not subject to the temperature limitations of the previously mentioned cellulose-base materials. It is used successfully on bands operating in oil. It is particularly adaptable for double-wrap bands, because of its flexibility.

Woven asbestos materials are the only ones of the resilient family that will resist the crushing effect of the high local unit pressure that usually occurs near the ends of the band. The true friction of woven materials is, in general, in the range of resilient materials, but on wrapping bands the apparent output is much higher.

Although most woven asbestos material contains metallic wire embedded in it, it has been found that, under certain conditions spectacular increases in wear resistance have been obtained when this wire was omitted. For example, in the oil fields, where long, severe engaging times are encountered, the heat soaks into the lining so much that binder breakdown is encountered. This occurs even though the mating steel drums are water-cooled and are designed to draw off most of the heat. When the metallic wire was left out of the yarn in the surface

Getting Tougher

Clyde S. Batchelor and Edward L. Carey,

Raybestos Division, Raybestos-Manhattan, Inc.

Based on paper, "Friction Facts, Fortes, and Foibles," presented at the SAE Annual Meeting, Detroit, Jan. 12, 1954.

plies of the friction material, much less heat was absorbed by the material. Under certain conditions, this resulted in greatly improved wear resistance.

Semimetallic Material—Semimetallic friction materials consist of a synthetic resin-bonded material containing 40% or more of metallic powders (mostly copper). Lead is also added to act as a lubricant. In addition, the material may contain asbestos, graphite, and friction-augmenting agents.

Properly compounded semimetallic friction materials have engagement characteristics comparable to those of the resilients. The good engagement characteristics are thought to be due to the lubricated copper film that develops on the operating surface. In any case, they function satisfactorily as clutch plate materials and operate smoothly on bands in oil where other materials chatter.

The friction range is 0.08–0.065. There is some drop-off in friction during the life of the material, but under relatively severe operating condit.ons frictional stability is one of its outstanding strong points.

Durability is much better than for the resilient types, but inferior to that for the full metallics under severe service.

It can be made in thin, conformable sections readily adaptable to bands, plates, cones, and intricate shapes.

Rigid Molded Material—Rigid molded friction materials contain asbestos fiber matrix, lubricants, friction-augmenting agents, and a fully cured thermosetting organic binder.

Engagement characteristics are definitely inferior to those for the resilient and semimetallic materials, but they are still generally acceptable.

The coefficient of friction lies between that for the semimetallic and the resilient materials.

They have a durability comparable to that of the semimetallics, but they are inferior to full metallic material under high-temperature service.

They are capable of withstanding high pressures without crushing because they have high tensile and high compressive strengths, which makes them good structural materials. They are widely used where splines, teeth, lugs, and the like, are cut directly into the friction material to make them function as drivers or driven members. Where metallic cores are used, objectionable metallic clatter may occur. It is, however, nonexistent or damped out when the friction material itself becomes a structural member. These materials may also be riveted or cemented to steel members.

Economically, the material lies between the semimetallic and the resilient materials when cemented to metallic cores. When used as structural members, for example, with cut-in gear teeth, it usually provides the cheapest solution.

Fully Sintered Material—Fully sintered friction material is a matrix of sintered metal mechanically entrapping metallic and nonmetallic friction-augmenting agents. Sintered friction metal is almost invariably weak structurally and is always sold integrally bronzed to a steel reinforcing member. The most commonly used matrix is a bronze made of copper and tin, but many other matrices have been tried experimentally and adapted for minor production. Recently, iron and iron-bronze matrices have found limited applications because of their lower material cost.

Steel-to-steel and steel-to-bronze plates operating in oil in multiple-disc clutches have long been used in coal mining machinery.

The difficulty encountered with the wrought metals was the extremely low friction in oil. As a result, a clutch of large size with a good many friction surfaces was needed. Another difficulty was warpage, which often prevented full release. The greatest difficulty, however, was "galling or picking up a bug," which was, in effect, local welding of the contacting plates. The use of fully sintered-metal friction materials, with its higher coefficient of friction, gives greater capacity, and clutch warpage and galling are no longer problems.

Coefficient of friction for the fully sintered material falls in the range of 0.055–0.075. Compared

to sheet stock (0.035), this is relatively high, but it is far below that for the resilient materials and is appreciably below that for rigid and semimetallic types.

It finds its greatest application where the kinetic energy absorption per square inch of friction material is very high or where engagements occur on a repetitive cycle, with short time intervals. Under severe conditions, such as these, organic-containing materials wear too fast. On the other hand, the fully sintered metal will perform without appreciable increase in wear rate. This is, of course, due to the combined factors of better heat transfer through the friction material and the absence of a destructible bond.

In general, the frictional stability of sintered materials is good, there being little drop-off during the life of the material.

Disadvantages of the sintered metal include: higher specific gravity, bimetallic warpage when friction material is applied on one side of the steel core, and, occasionally, noisy operation.

Costs seem to depend upon the designs and production quantities involved. For example, a passenger-car transmission facing could be made cheaply, whereas a large master clutch plate for a tractor would be more expensive than other types.

Development in the sintered-metal field is centering on iron-base alloys. This is understandable, for copper powder costs 37¢ a lb, whereas iron powder costs only 15¢.

Some of the iron-base materials have proved particularly good in regard to friction stability and resistance to wear.

There are two types of iron-based sintered-metal friction material:

1. True sintered iron, which is an iron-carbon matrix containing friction elements.
2. A material containing a substantial amount of iron powder bonded together with a bronze bond.

Excellent frictional characteristics have been developed in both types. The bronze-bonded material has the better heat conductance, and the fully-sintered iron a slight price advantage.

A sintered metal has been developed for extremely heavy-duty oil operation. In most oil applications the oil film is maintained at least during the major part of the engagement.

Bonding—Two types of cement are used for the bonding of friction material to steel plates. One is a synthetic-rubber-resin cement and the other an all-resin cement. Each one is eminently satisfactory in its proper place.

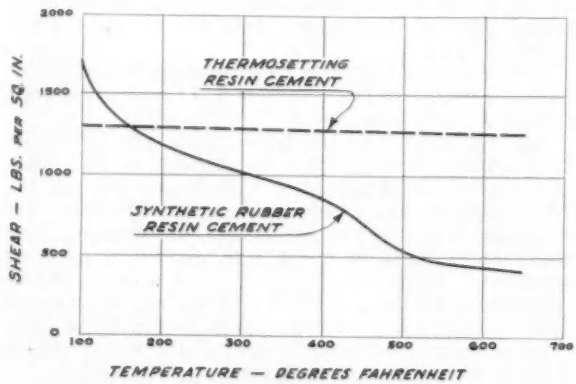


Fig. 2—Shear strength of bonding cements. Test method: steel laminated to steel, area 1 sq in., soaking time 1 hr

The synthetic-rubber-resin cement is easier to handle, because it sets up in situ and does not present a messy and expensive cleanup job, particularly around splines. Thus, it finds wide usage.

Fig. 2 shows the limitations of the rubber-resin cement. At some ill-defined temperature of 250–400 F at the cement line, friction material cemented with rubber-resin cement may come loose. These cements are, however, very successful when this limitation is taken into account.

Dry Operation

For dry operation there are two general types of molded friction materials, differing mainly in the method of incorporating the binder.

One is impregnated with oil or asphalt. This material is generally high in range of coefficient of friction, fair to poor in wear rate, depending on the type of service, poorest in engagement characteristics with respect to smoothness, but lowest in price.

The other type has the binder (usually primarily synthetic resin) incorporated directly into the mix. The material is then fused and densified by a hot hydraulic pressing operation. These materials are generally in the medium friction range. Durability may be fair to good, depending on the service encountered. The engagement characteristics are better than those of the first type, but are inferior to most woven materials. They are in the medium-price range.

Woven clutch facings have excellent engagement characteristics and good durability. They are high-priced by virtue of the fact that they are manufactured with the more expensive long-fiber asbestos.

The composition of semimetallic material has already been described under wet operation. In dry operation it is classified as having medium friction, with fair to excellent qualities in regard to engagement characteristics and durability. It has relatively high heat conductance. It is also quite versatile, since it can be supplied for riveting or can be bonded to steel members. Its price is high because of its copper content.

The fully sintered materials are often of the same composition as for wet operation. Friction can be varied widely in this class. Durability is good to excellent. This durability is sustained at high-ranges. Engagement characteristics are good. For most applications, price is generally higher than for any other type.

Ceramic Materials

The successful use of ceramics by the aeronautical industry has focused attention on its possibilities as a friction material. A superficial study showed that many ceramics have extremely high temperature resistance. It seemed necessary only to incorporate friction agents with this material to produce a product with phenomenal properties.

In practice this was not easy, since most friction additives were found to react with the ceramic at the 3200–3500 F firing temperatures used. This resulted in a loss of the desirable properties.

Because of the low resistance to heat shock, some

form of retainer is generally used. For example, the ceramic may be enclosed in a steel cup or as inserts in a friction compound.

Three types of ceramics could be used:

1. A derivative of the sintered-metal family, which consists of a sintered-metal matrix containing ceramic particles.
2. A ceramic base in which a metal is entrapped.
3. Pure ceramic with or without friction additives.

To date, testing has been confined to aircraft brakes, where there is an urgent need for better material. It has been found that wear was only one-tenth that with the best organically bonded materials, operating on the same test cycle. In general, the materials have low coefficient of friction—0.20–0.25, compared to 0.30–0.35 for heavy-duty organically bonded aircraft brake material. Compared to sintered metals, the friction is about the same and the durability is better.

Preliminary tests have shown that the limiting factor for a ceramic friction assembly is not the ceramic but the mating member. On a spot-type brake, where local heat generation is extremely high, the friction surface or friction films developed are so fluid that they act as lubricants. This points toward different design requirements when ceramics are used, better mating members, or a higher coefficient of heat transfer in the ceramic friction materials. Better coefficient of heat transfer can be obtained by the use of metal additives. Unfortunately, in many designs it is not desirable to absorb much heat through the friction material, so this is not a panacea for all heat troubles. These metal-bearing ceramics have generally shown greater resistance to heat cracking with comparable friction properties to full ceramics.

Preliminary studies indicate that direct application of the ceramics to existing designs in most fields will be impractical, both from mechanical attachment and engineering standpoints. The extremely good wear resistance of ceramics points toward the possibility of smaller all-round design. The friction industry offers ceramics as a material that shows potential promise for those willing to design specifically to utilize fully their unique characteristics.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Accumulation of Carbon May Cause Loss of Friction

Excerpts from discussion by

J. G. Oetzel
Warner Electric Brake & Clutch Co.

I WONDER if, in Fig. 1, the loss in coefficient isn't due to the gradual accumulation of carbon on the face of the friction material, this carbon being formed by cracking of the oil, or even of the surface layer of the friction material itself, by the temperatures reached in the interface region.

New Materials Have High Coefficient of Friction

Excerpts from discussion by

L. P. Kane
S. K. Wellman Co.

THE most pressing need is for new and improved materials for oil operation. To meet this, research and test facilities are concentrated toward this goal. The coefficient of friction ranges shown in the paper for fully metallic in oil generally agree with our findings for current production materials. Recent developments, however, indicate we can get an appreciable gain in this value. In Fig. A we have added the results of tests on two of these materials to one of the authors' figures.

The curves illustrating materials A and B are the original shown by the authors and both fall below a 0.08 coefficient of friction value. Material C offers a value of about 0.085, with remarkable consistency over a 1000-stop test. Material D exceeds a value of 0.09. These results have been reconfirmed over a number of tests and in several field installations. Noteworthy also is the fact that, in spite of the coefficient of friction increase, the wear rate has not been affected and, if anything, is slightly lower.

Cork Coefficient of Friction In Oil Varies with Pressure

Excerpts from discussion by

R. M. Hill and J. W. Oren
Armstrong Cork Co.

THE wet application of resilient facings is so complicated that it is not possible to state that a material has a certain coefficient of friction. Various operating factors built into a particular application will affect the coefficient of friction as much as 100%. Proper recognition of these factors is neces-

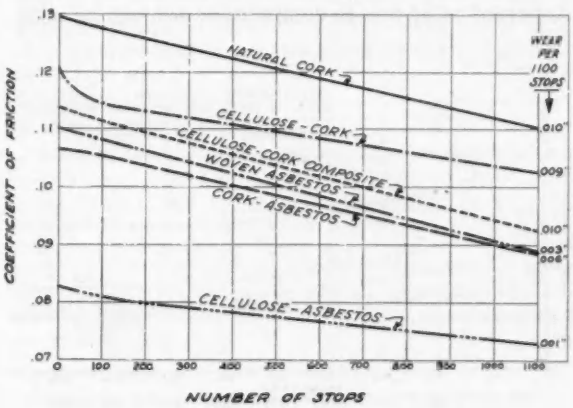


Fig. A—Properties of friction materials in oil operation—fully metallic type

sary for successful functioning of this type of facing material. The shape of the clutch plate, speed of operation, facing pressures, thickness of the facing, density and composition of the material are typical examples of critical factors.

The shape of the plate is all-important. If segments of a densified cork composition are cemented to a flat plate having radial slots with the facing having sharp edges at the slots, these edges will act as wipers to eliminate the separating oil film rapidly during the engagement period. However, if the same cork composition is cemented to a waved plate having no slots, the facing will ride on the oil film for a much greater length of time—thus the oil film plays a much greater role in determining the operating coefficient of friction. Differences of conditions of operation such as this must be considered when comparing data obtained in various laboratories. In our work with the flat-slotted type of plate, we found that, as the normal facing pressure is increased, the operating coefficient of friction decreases. This change probably is caused by a change in the density of the cork as the pressure increases. However, work at other laboratories with nonslotted, waved plates resulted in an increase in coefficient of friction with increase in pressure. In the flat-slotted-plate application, the removal of the separating oil film by the facing edges permitted full contact between the facing and steel at all pressures, so that the facing surface was not greatly affected by the oil film. However, with the waved plate, it is believed that the facing tends to ride on a film of oil. Thus, increased pressure is necessary to break through the oil film and allow the facing to develop its coefficient of friction.

Contrary to former thoughts on the laws of friction, the coefficient of friction of cork materials (immersed in oil and mounted on flat surfaces) varies with pressure. Fig. B shows a typical group of curves for a cork composition. Note that the coefficient decreases with increasing pressure. The coefficients quoted in the authors' paper appear to be on the low side for cork facings, which might be due to the use of high pressures in testing.

Service reports have shown that cork facings sufficiently lubricated, cooled, and operating in the recommended pressure range experience no appreciable wear; the slitting knife marks on the facing surface being still visible after months of service. Apparent wear due to compression set can be minimized to the point where it is not objectionable by using thin facings and a densified cork material. The densified cork will have a lower coefficient of friction than a soft cork facing but it is a relatively stable, low compression set material and the advantages of its use greatly overweigh its slight loss in capacity. Frictional values as shown in Fig. B are for a dense, relatively hard cork facing, which is widely used in automotive transmissions.

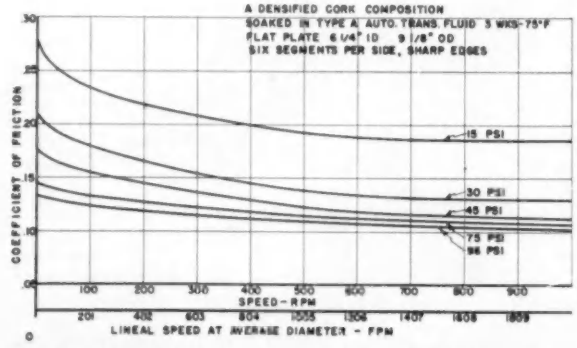

A DENSIFIED CORK COMPOSITION
SOAKED IN TYPE A AUTO. TRANS. FLUID 5 WKS-75°F
FLAT PLATE 6 1/4" ID 9 1/8" OD
SIX SEGMENTS PER SIDE, SHARP EDGES
COEFFICIENT OF FRICTION
15 PSI
30 PSI
45 PSI
75 PSI
95 PSI
SPEED - R.P.M.
LINEAL SPEED AT AVERAGE DIAMETER - F.P.M.

Fig. B—Coefficient of friction versus speed for various facing pressures

Accelerated testing of resilient facing materials should be used with discretion and should be avoided when possible. As soon as any one condition is exceeded that might be destructive to the organic material but which would not be met in practice, the accelerated tests become of no value. Extended periods of slip, excessive pressures, and the like, are to be avoided.

Excellent Properties Make Cork-Paper Plate Popular

Excerpts from discussion by

H. W. Schultz

Moraine Products Division, GMC

IT is interesting to note in Fig. 1 the rather high dynamic coefficient of friction obtained from natural cork. In general, it is slightly higher and far more stable than we have recorded. This may be because of a difference in element design or testing procedure, or possibly because of the extremely wide difference in density, usually apparent in one piece of natural cork with respect to another.

We used a single clutch plate operated in one of our inertia dynamometers for 5400 cycles at 3 cycles per minute, with a unit facing pressure of 125 psi, and at an oil sump temperature of 250 F, the engagement cycle is from 1800 rpm. In this kind of a test the dynamic coefficient of friction for natural cork was determined as 0.13 at the beginning and 0.08 at the end of the test. As a further comparison, we might mention that resin-bonded 20 to 40 mesh cork of 30 to 32 lb density, which is commonly used in this type of application, has a more uniform dynamic coefficient of friction, starting at 0.09 and ending at 0.07 as tested on the same plate design and in the same manner. The static as distinguished from the dynamic coefficient of friction for resin-bonded sheet cork as used on various clutch plates is extremely high compared to other conventional materials.

We find the dynamic coefficient of friction of cellulose-cork composite or the cork-paper plate to be extremely stable and uniform in output from the beginning to the end of the 5400-cycle test. It normally starts at 0.11 and ends at or very close to the same value. The loss in thickness of the plate ranges from 0.003 to 0.008 in. Again, these values were taken at 125 psi unit pressure, or 95 psi line pressure.

When line pressures are varied from 95 to 50 psi or the unit loading is varied from 125 to 83 psi the cork-paper plate has far less difference in friction properties than any other material we have tested. The low unit pressure coefficient of friction ranges from 0.07 to 0.08. This fact is of considerable importance in some transmission applications.

The primary reason for the popularity of this

plate is pleasability in engagement and performance. This, of course, applies directly to transmissions designed especially for its use. Another major consideration of this plate is its comparatively low cost.

The fact that extremely large quantities of such elements are produced each day—and the fact that millions are serving their purpose well throughout the field with a very minimum amount of service—would indicate that it is an outstanding combination. Its major limitation is comparatively low heat resistance. Engineers are designing transmissions today with this fact in mind, and are making corrections accordingly.

While discussing resilient compositions we should not overlook the Buna-N-cork compounds, which are in common use today for various lock-out-plate applications. This material can be processed with various ratios of Buna-N- to cork and to various densities.

Semimetallic Friction Materials

In general, we find overall frictional properties of semimetallic materials are considerably different from those of the resilient type. While its initial coefficient of friction at 125 psi unit loading may be equivalent to the cork-paper element, it generally does not retain this factor throughout the duration of the test. We have observed its coefficient of friction dropping to as low as 0.055 at the conclusion of 5400 cycles. When unit loads on the facing are reduced from 125 to 54 psi which is not unusual in some transmissions, its coefficient of friction drops considerably more than that of the so-called resilient plate. This could possibly be one reason why plates of this composition are not interchangeable with the widely used resilient type.

Highway Construction . . .

. . . is in critical need of comprehensive load-test research. With billions to be spent for roads, let's get engineering facts for guidance.

Based on paper by **A. E. Johnson**, Arkansas State Highway Department

FOR the last several years, the American Association of State Highway Officials has been working on a proposed comprehensive load research project. It is estimated to cost some $8 to $8½ million, but this is only one-fiftieth of 1% of the price tag on the backlog of needed road, street, and highway improvement. Money spent on this program to give highway engineers a better knowledge of structural design needed for various loadings can be well spent.

The overall purpose of this AASHO project is to develop engineering facts and criteria which can be used:

1. In the design and construction of new pavements.
2. In preservation and betterment of existing pavements.
3. As an engineering basis for enactment of adequate and equitable legislation covering allowable loadings and highway tax structures.
4. To give manufacturers information as to types and capacities of highway vehicles giving transportation of optimum overall economy.
5. To provide specific information as to engineering problems, costs of building and maintaining highways of different capacities, and increased taxation to cover cost of higher capacity highways which may be related to the cost of vehicle operation.

The AASHO project proposes that factual engineering data be obtained through laboratory controlled construction of specially designed test sections, subjected to moving controlled loadings with sufficient instrumentation and competent staff to evaluate and analyze fully the results of the research. (Paper "Comprehensive Load Test Research Critically Needed in the Highway Field" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Discussion

A. F. Stamm, Chrysler Corp.

Our knowlegde of highway design and construction is not equal to today's needs. The test schedules and procedures presented will yield much valuable information and every possible encouragement should be given to their immediate and full implementation.

V. M. Drew, Freuhauf Trailer Co.

I am not yet ready to accept the contention that our present highway system is either entirely obsolete, unnecessarily damaged, or requiring renewal or replacement to any such extent as is being currently publicized. Is there any possibility that we may in the not too distant future reach a point where our transportation aspirations will actually exceed the economic stability of the very foundation on which they rest?

Gavin W. Laurie, Atlantic Refining Co.

Tests should be used as indicators and not as standards. Building roads to outdated standards is the cause of the trouble we are in today.

Simplicity Alone Won't Get

ALTHOUGH the first experimental gas-turbine road locomotive was placed in service about the same time as the first road locomotive diesel, its development has been slow. Mostly this is due to the greater metallurgical problems encountered with gas turbines. But the fact remains that until the gas-turbine locomotive proves cheaper to operate than other types of locomotive, it won't reign on Class I railroads. For while the inherent simplicity of a gas turbine is intriguing, this in itself is not enough to win the job away from diesel and electric locomotives.

Only time will tell whether the gas turbine can be operated for less than diesel and electric units. But as of today, these things are indicated:

- With a readily available supply of cheap gas-turbine fuel and carefully supervised operation, fuel cost of a gas-turbine locomotive isn't much higher than that of a diesel locomotive.
- Crew wages with a diesel locomotive may be less if its extra handling capacity is exploited.
- Maintenance cost of the gas turbine and diesel engine may well decide which gets the locomotive job.
- To meet competition, gas-turbine locomotives will have to be suitable for general use. They can't be limited to special applications.

Table 1—Delivery Dates of Union Pacific Gas-Turbine Locomotives

Locomotive Number	Delivery Date	Where
51	1/31/52	Green River
52	4/ 9/52	Green River
53	5/ 7/52	Green River
54	6/ 4/52	Green River
55	7/ 9/52	Green River
56	8/13/52	Green River
57	5/20/53	Los Angeles
58	7/ 3/53	Green River
59	8/12/53	Green River
60	8/27/53	Green River

The available and published performance records of gas-turbine locomotives are limited to two Swiss, one English, and seven Union Pacific Railroad units (although ten UP units are now in service, see Table 1.) Data describing these units, as well as the General Electric prototype of the Union Pacific units and an experimental Westinghouse unit, are given in Table 2.

The large Union Pacific contingent naturally is of great interest. These locomotives, like all of their European "brothers," use the open cycle; have axial-flow turbines and compressors; and employ electric power transmissions.

Locomotive Requirements

Before comparing the UP locomotives with standard diesel and electric units, it might be well to list the requirements for locomotives in Class I railroad service. These may be summarized briefly as follows:

1. The locomotive should consist of units that can be readily assembled to give horsepower outputs ranging from 1500 hp to over 6000 hp.

2. Axle loads and profile of the units should broadly comply with the permissible axle loads and clearances of practically all Class I railroads.

3. The locomotive should have good fuel economy over its normal operating range.

4. Transmission capacity should be adequate to fully develop the locomotive horsepower rating over

Turbines Train-Tugging Job . . .

. . . To rule in the realm of Class I railroads, gas-turbine locomotives must also be versatile and cheaper to operate than diesel- or electric-powered units. Incomplete evidence indicates that maintenance costs will decide this battle for supremacy.

P. A. McGee, Consulting Engineer

Based on paper "Locomotive Power and Performance Requirements with Special Reference to Gas-Turbine Locomotives" presented at SAE National Diesel Engine Meeting, Chicago, Nov. 3, 1953. Complete paper will appear in 1954 SAE Transactions.

Table 2—European and American Gas-Turbine Locomotives in Service

1.	Railroad	Swiss Federal Railway	Western Region	Western Region	Demonstrator	Demonstrator	Union-Pacific
2.	Turbine Builder	Brown Boveri	Brown Boveri	Metropolitan Vickers	Westinghouse	General Electric	General Electric
3.	Locomotive Builder	Swiss Loco. Works	Swiss Loco. Works	Metropolitan Vickers	Westinghouse	General Electric	General Electric
4.	Electrical Builder	Brown Boveri	Brown Boveri	Metropolitan Vickers	Westinghouse	General Electric	General Electric
5.	Locomotive Rated HP	2200	2500	3000	4000	4500	4500
6.	No. Turbines	1	1	1	2	1	1
7.	No. Generators per Turbine	1	1	3	2	4	4
8.	No. Combustors per Turbine	1	1	6	12	8	6
9.	No. Stages per Turbine	6	7	5	8	2	2
10.	RPM of Turbine Unit	5200	5300	7000	8750	6900	6900
11.	Type Regenerator	Cross Flow	Cross Flow	—	—	—	—
12.	Top Cycle Temp., F	1110	1100	1300	1350	1290	1290
13.	Efficiency (Full Load), %	16	15.8	18	16.9	16	16
14.	Wheel Arrangement	1A-B-A1	AIA-AIA	C-C	B-B-B-B	BB-BB	BB-BB
15.	Total Weight, lb Max	203,000	266,890	290,000	494,000	530,000	550,000
16.	Weight on Drivers, lb	142,000	177,920	290,000	494,000	530,000	550,000
17.	Length Overall, ft-in.	53-10	63- 0	66- 9¼	77-10	83-8	83-6½
18.	Wheelbase, Total, ft-in.	41-10	50- 1	53- 0	62- 9	68-3	68-1
19.	Wheelbase, Rigid, ft-in.	11- 1	11-10	15- 0	9- 0	9-4	9-4
20.	Width, ft-in.	9- 6	9- 3	9- 0	10- 2½	10-7	10-7
21.	Height, ft-in.	13-11	13- 4	12-10	15- 0	15-4	15-5
22.	Cont. Tractive Effort, lb	14,000	12,400	30,000	52,800	77,800	105,000
23.	Mph at Cont. Tractive Effort	47.5	64.0	30	23	18.2	12.9
24.	Max mph	70	90	90	100	69.3	65
25.	Railroad	Swiss Federal Railway	Western Region	Western Region	PRR-MKT-C&NW	PRR-Nickel Plate-UP	Union Pacific
26.	Date Order Placed	March 1939	October 1946	July 1947	Demonstrator	Demonstrator	December 1950
27.	Date First Operated	August 1941	October 1949	February 1952	1949	November 1948	See Table 1
28.	No. of Locomotives	one	one	one	one	one	ten

Table 3—Modern Gas-Turbine, Diesel and Electric Locomotive Characteristics

Type Locomotive	Hp/Unit	Wheel Arrangement	Wt.—1000 lb		Cont. Rating		Max Speed	Ratio Max Speed to Cont. Speed
			Per Axle	Total	Tractive Effort lb	Speed mph	mph	
	(1)							
Gas-Turbine	4500	B-B-B-B	68.8	550	105,000	12.9	65	5.0
	(1)							
Diesel	1600	B-B	62.5	250	52,500	9.3	65	7.0
	3200	2(B-B)	62.5	500	105,000	9.3	65	7.0
	4800	3(B-B)	62.5	750	157,500	9.3	65	7.0
	6400	4(B-B)	62.5	1000	210,000	9.3	65	7.0
AC	(2)							
Electric Motors	2500	B-B	60.0	240	35,400	26.5	65	2.1
Electric Motors	5000	2(B-B)	60.0	480	70,800	26.5	65	2.1
DC	(2)							
Electric Motors	3000	B-B-B	62.5	375	66,000	17	63	3.7
Electric Motors	6000	2(B-B-B)	62.5	750	132,000	17	63	3.7

(1) Gas turbine and diesel locomotive Hp rating is input to traction generator.
(2) Electric locomotive Hp rating is at the driving wheels.
Tonnage ratings are normally proportional to weight on drivers.

a large speed range. This is necessary to permit operation on level, rolling, and grade profiles.

More specifically, the transmission of a Class I railroad locomotive should be capable of delivering a tractive effort equal to 25% of the weight on the driving wheels for starting. It should also be able to deliver continuously a tractive effort of at least 18% of the weight on the drivers while in freight service.

In the final analysis, the ratio between the permissible maximum and minimum locomotive speeds best defines the capacity and flexibility of a locomotive transmission. This ratio gives the range of speed over which the full horsepower of the locomotive can be employed continuously.

Now, keeping these facts in mind, let's see how the characteristics of the UP gas-turbine locomotives compare with those of standard diesel and electric locomotives.

Transmission capacity and flexibility of these units are compared in Table 3. Shown are the horsepower per unit, wheel arrangement, weight per axle, total weight, tractive effort and speed at continuous rating, maximum permissible speed, and the important ratio of maximum permissible speed to permissible continuous speed.

Consider first the characteristics of standard diesel locomotives. These have a weight of 156 lb per hp and could be designed to weigh less than 130 lb per hp. Their continuous rating is nearly 21% of the weight on the drivers. Thus, even at 156 lb per hp, these units are practically foolproof. Their ratio of maximum speed to continuous speed of 7.0 gives a very wide operating range.

The Union Pacific gas-turbine locomotives have a weight of 122 lb per hp and a correspondingly low continuous rating of 105,000 lb at about 19% adhesion. Ratio of maximum to continuous speed is 5.0. Principal difference between the 4500-hp gas-turbine and the 4800-hp diesel locomotive is that the diesel has 50% more transmission capacity, and with equal axle loads, could haul 50% more tonnage on a given grade.

The AC and DC electric locomotives have, respectively, continuous tractive efforts of 14.7% and 17.6% of the weight on the driving wheels. Their ratios of maximum to continuous speed are 2.5 and 3.7, respectively. The standard diesel locomotive of 3200 or 6000 hp has 40% to 50% more transmission capacity than the corresponding electric units. Thus, the standard diesel can haul 40 to 50% more tonnage on a given grade. The favorable weight ratio of electric units, therefore, is obtained at a great sacrifice in hauling capacity.

Tractive effort-speed curves for diesel, electric, and UP gas-turbine locomotives are shown in Fig. 1. Due to the variation in horsepower caused by temperature and/or elevation changes, the characteristic curve of the gas-turbine locomotive is represented by an envelope covering the extreme ranges of possible operation. The cross-hatched area shows the range of operation between the maximum output of approximately 6000 hp at 20 F and 6000 ft elevation and the output of 4150 hp at 100 F and 1000 ft elevation. This hatched area might be extended to include a 3550 hp output at 120 F and 1000 ft elevation.

It will be noted that the continuous tractive effort of the gas-turbine locomotive can be delivered at a speed varying from 11.6 to 16 mph, depending upon atmospheric conditions.

Fuel Consumption Picture

The next point of interest in connection with the 4500-hp Union Pacific gas-turbine locomotive is its fuel consumption at various horsepower outputs.

The full-load fuel consumption of this locomotive is said to be between 550 and 600 gph of 18,600 Btu-

per-lb fuel. At idling the fuel consumption is reported to be about 200 gph. Based on these values, Fig. 2 gives the fuel consumption of the UP gas-turbine locomotive over its operating range (at 80 F and 6000 ft elevation). The corresponding fuel consumption curve for a typical 3-unit 4800-hp diesel locomotive is shown for comparative purposes.

At 4000 hp output, fuel consumption of the gas turbine is 550 gph, whereas the diesel consumes only 250 gph. Thus, at this load, ratio of fuel consumption of the gas turbine to the diesel is 2.2 to 1. At idling, the ratio becomes 8.0 to 1.

The average fuel consumption rate of the gas-turbine locomotive is given as 335 gph. The corresponding diesel rate is about 100 gph. This gives an average fuel consumption ratio of gas turbine to diesel of 3.35 to 1.

These values are significant. They indicate that the UP gas-turbine locomotive would consume over three times as much fuel as a diesel locomotive in comparable service.

With commendable foresight, however, the Union Pacific has arranged its gas-turbine locomotives so that dead-head and certain switching movements can be performed by a small diesel motor-generator set through a few traction motors. Each locomotive is also arranged so that the gas turbine can be closed down or started up from the control position of the operator. This, in turn, permits the turbine to be shut down on long coasting runs, resulting in a great saving in fuel.

In actual operation in 1952 on the Green River-Ogden run, fuel consumption of locomotives 51 and 52 was 14.0 to 15.3 gal of residual fuel and 0.55 to 0.88 gal of diesel oil per locomotive mile. Fuel consumption averaged 4.28 gal per 1000 gross ton miles.

On this run of 175 miles, the first 65 miles east of Ogden is a "helper" section of approximately 1.14% grade. This relatively long "helper" stretch naturally makes it difficult to estimate fuel consumption on a ton-mile basis. Also, diesel fuel-consumption information on this run is not readily available.

However, the national average of diesel fuel consumption in 1952, including locomotive and tender, was 1.6 gal per 1000 gtm. Allowing for locomotive weights, the national fuel consumption on a trailing basis would be 1.75 gal per 1000 gtm. At this rate, the gas-turbine/diesel fuel ratio becomes 2.45 to 1 instead of 3.35 to 1, as indicated in Fig. 2.

Diesel fuels or a distillate would give the best maintenance results in gas-turbine locomotives operating at temperatures above 1200 F. However, the Union Pacific fuel-consumption figures show that it is essential to burn the cheapest fuel possible in order to compete with the diesel. (Naturally, however, consideration must be given to maintenance and reliability that result with a particular type of fuel.) The Union Pacific Railroad is in the fortunate position of having readily available a supply of residual Bunker C fuel at relatively low rates.

Whole Thing May Rest on Maintenance Costs

No data on the out-of-pocket operating costs of the UP gas-turbine locomotives have been published. There are indications, however, that crew wages

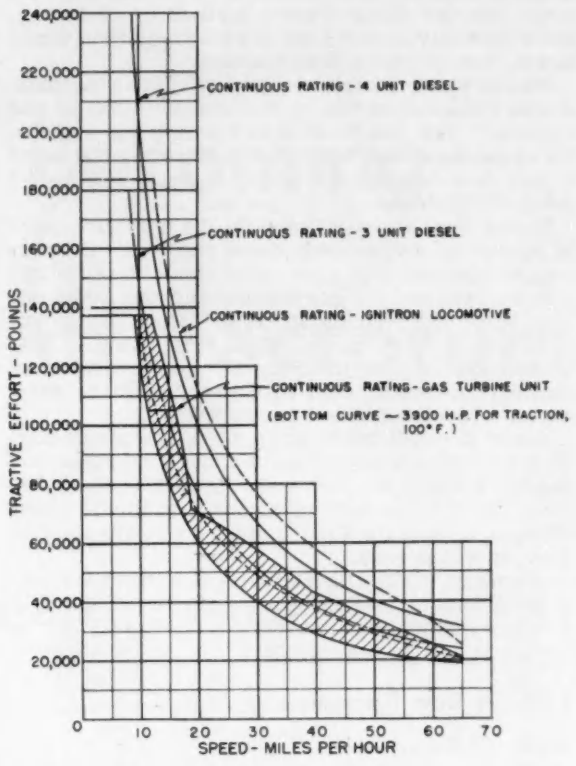


Fig. 1—This shows tractive effort versus locomotive speed curves for electric, diesel, and Union Pacific gas-turbine locomotives

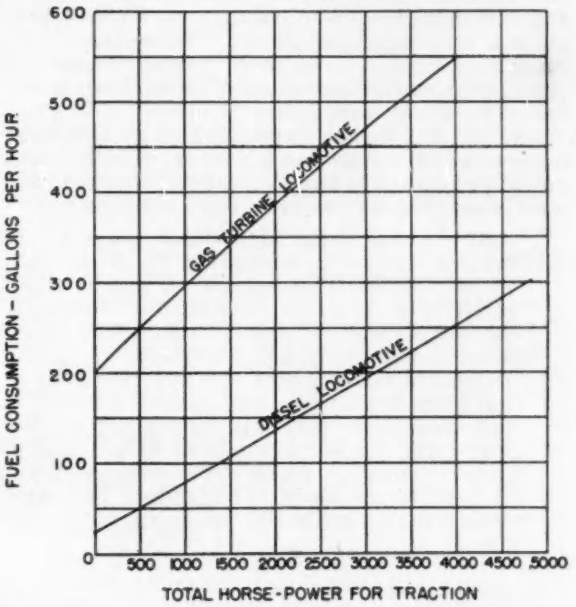


Fig. 2—Comparison of approximate fuel consumption of Union Pacific gas-turbine locomotive (at 6000 ft elevation and 80 F air temperature) and standard 3-unit diesel locomotive

with a diesel locomotive would be less if its extra hauling capacity were exploited. With existing fuel costs and the Union Pacific method of operating, there probably is only a small advantage with diesel power, not counting maintenance.

What's more, there are many promising developments aimed at reducing fuel consumption of gas turbines. The powdered-coal burning gas turbine, for example, would, with coal at $5.50 per ton, have a fuel cost less than that of a diesel locomotive using distillate fuel at 10¢ per gal.

In the final analysis, possibly the only difference in operating cost between these two types of power may be maintenance cost. And this difference can only be between the gas turbine and the diesel engine since the locomotive transmission equipment is similar in both cases. With this in mind, it is interesting to note that the UP gas-turbine locomotives are maintained with practically the same facilities used for diesel locomotives.

When it comes right down to it, the application of gas-turbine locomotives to Class I railroads will depend entirely on economics in all classes of service. If the gas-turbine locomotive should prove cheaper to operate than diesel or electric locomotives, it will prevail.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Excerpts from Discussion by

Walter C. Hadley, Consultant

There is no possibility that the gas-turbine locomotive could replace the diesel in the way that the diesel has recently replaced steam.

For one thing, practically all Class I railroads are now well equipped with nice new diesel locomotives and new shops to care for them, all of which represents a very large investment. For another, the possible savings in going from diesels to gas turbines are nowhere near as large as the savings obtained by going from steam to diesel.

Nonetheless, **the gas turbine has many attractive features which should find it a useful place in many railroad applications once its teething troubles have been brought under control. Two of these are:**

1. **Ability to use cheap fuel.** While present gas-turbine fuel requirements are far from clear, there is no question but that it will be much easier to burn cheap fuels in the continuous turbine combustion process than in the intermittent diesel combustion process.
2. **Decreased maintenance.** Gas turbines admittedly are not getting any simpler. But it is not likely that they will ever approach the very large number of precision parts found in diesels, most of which reciprocate and are subject to all kinds of wear and breakage. This can only mean less maintenance on turbines.

F. Fahland, Union Pacific Railroad

The author makes the statement that, "the Union Pacific is in the fortunate position of having readily available a supply of residual Bunker C fuel at relatively low rates". I wish to elucidate this statement.

Fuels used in the UP gas-turbine electric locomotives are purchased at the current market price for the territory in which the fuel is obtained. We have found no way to get fuel from oil companies at less than market price. It has been necessary for us to purchase Bunker C modified fuel on the West Coast where cost of this fuel is the highest on our railroad.

But even with this high-priced fuel, the cost of fuel for the gas turbines compares favorably with diesel fuel cost on a 1000 gross ton-mile basis.

As we all know, fuel costs are just a part of the cost of operating a locomotive. Cost comparisons should also include lubrication and maintenance costs.

We in the mechanical departments of railroads believe that the cost of maintaining all locomotives, including diesels, is too high. It is our responsibility to find ways to reduce these costs.

Statements by the author that the 1500-hp diesel unit (used in multiples) is best suited for American railroads appear to be made for consumption of diesel-locomotive builders.

The size of the 1500-hp diesel unit was apparently established by the fact that diesel-engine builders were unable to produce a larger high-speed diesel suitable for railroad service. (This has changed in recent years.) **This small engine has forced railroads to use multiple units with their multiple maintenance problems.**

In addition, handling, turning, and directional testing of multiple units at terminals involves more work, time, and cost.

The author places considerable emphasis on the fact that three diesel units of 1500-hp each can haul 50% more tonnage on a given grade than a 4500-hp gas-turbine electric locomotive. Actually, the diesel locomotive with its low horsepower/weight ratio and ability to drag just about all the tons it can start has a shortage of horsepower for acceleration of trains. The gas-turbine electric locomotive, on the other hand, with its higher horsepower/weight ratio can accelerate any train that it can start.

In conclusion, we have found that the lighter gas-turbine electric locomotives accumulate as many gross ton-miles of freight as diesels. In other words, they can do equally as much work as three diesel 1500-hp units.

Edson Barlow, Rail Branch, Operations Research Division, Fort Eustis, Va.

Question: In the long run, won't the economic possibilities of the gas turbine depend more on increasing the efficiency of the turbine rather than obtaining cheaper fuel?

Answer: Yes.

Question: What is the comparative fuel cost per 1000 gross ton miles of the gas turbine and diesel on the Union Pacific?

Answer: Fuel cost for the diesel is approximately the same as that of the gas turbine in the same service.

Small Turbine Becoming General Aircraft Factotum

L. W. Biwer and R. L. McManus,
Aircraft Gas Turbine Division, General Electric Co.

Excerpts from paper, "Small Turbines—The Heart of Modern Aircraft Accessory Power Systems," presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 2, 1953.

THE small, high-speed turbine wheel is well on its way to becoming the heart of modern aircraft accessory systems. Having made its premiere as a means of cabin conditioning and pressurization, it is now the main component of a much more far-reaching system. The accessory jobs of which the small turbine is capable are so diverse that it has been pretty well defined as the main component of a muscular system for the generation of electric power, refrigeration, the movement of fluids, and the production of torque.

Generation of Electric Power

Perhaps one of the most important aircraft accessory jobs is the generation of electric power, because so many other services are dependent upon it. Perhaps the most important question about this most important job is, "How shall we do it?" In the substantial trend to constant-frequency a-c electrical systems, the airframe manufacturer has his choice of electing to drive his alternators with air turbines or with engine-driven constant-frequency systems. Our company has spent considerable effort in an endeavor to determine what system is best from the standpoint of the airplane and has come up with the not exactly helpful conclusion that that there is *no universal answer.*

We have concluded that the decision is profoundly influenced by the accessory power system problems associated with each particular airplane. To make the proper decision, it is necessary to make a rather detailed system comparison study of each airplane as it comes along.

Most of the airframe manufacturers have accepted this conclusion and now perform this system comparison study on each airplane to dictate their choice.

Factors Favoring Selection of Air Turbine—Outstanding considerations influencing selection of an air turbine drive are:

1. Reduced parasite drag: An air turbine can be located at any convenient or remote spot in the aircraft. Engine-driven systems pose the requirement that they must be located close to the scene of shaft power at the front end of the engine. The congestion in this area frequently results in a frontal area increase when all the necessary accessories have been installed. This is particularly acute when a peripheral mounting has to be utilized. In such instances, it is necessary to penalize the engine-driven system due to parasite drag. Because of the remote location of the air turbine, no parasite drag penalty is incurred.

2. Multiple use of ducting: Aircraft that double up on duct utilization frequently show an advantage for an air turbine accessory power system; since, by making the pneumatic ducting larger, the same ducts can be used for conditioning and for the

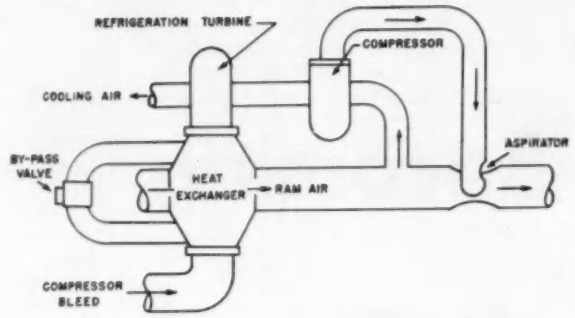


Fig. 1—Refrigeration system utilizing small turbine

air turbine drives as well. Also, the same advantage has been demonstrated by doubling up on duct utilization for thermal de-icing and for accessory drives.

The outstanding example of this factor was a twin-engine airplane where ducts were routed from wing-mounted engines to fuselage. A 2-in.-diameter duct system was required for conditioning units. A 4-in.-diameter system could service both conditioners and air turbine drives. As a result, the accessory power system was charged with only 65% of the duct weight, since the remaining 35% would have been necessary for the conditioning system anyway.

3. Advantageous location: In a multiengine aircraft, the air turbine can be located close to the load center of the airplane. Since a major portion of the auxiliary power is used in the fuselage area, a major weight penalty can be incurred when engine-mounted accessories are used, due to the necessarily long routing length for heavy supply lines. The use of the air turbine, in such instances, results in a major weight saving, as well as localization of service troubles. In addition, it can result in a substantial cost saving in power transmission equipment. The weight saving is somewhat offset by the fact that the air turbine must be provided with a duct; but, as considered above, this ducting can usually be obtained at very small cost to the accessory system when doubled up with conditioning, de-icing, or some other aircraft service.

The question of reliability needs to be considered in connection with accessory power for multiengine aircraft. Ducting design for an air turbine can be made such that it can be operated from any engine. Hence, accessory power availability is always greater for an air turbine system under conditions of engine failure.

Because of the greater length of pressure lines and electrical conduits, the use of engine-driven accessories on a multiengine airplane poses a greater probability of service failures. Air turbine drives, on the other hand, use relatively short lines with a resultant increase in reliability.

4. Adaptability to ramjet and turboramjet propulsion system: Ramjet aircraft, and aircraft using turbojets with ramjet afterburner, usually find an advantage for an air turbine accessory system. This is, obviously, due to the fact that a pneumatic energy source is available under all conditions, while engine shaft power is not.

Factors Unfavorable to Selection of an Air Turbine Drive—For certain installations where the main engine is operating at a critical point or where an engine-driven system can be installed without frontal area increase, the air turbine may show up at a disadvantage.

Critical engine bleed: In some installations, the main engine operating point for one or more flight altitudes finds the compressor operating in a critical area. Bleed flow for conditioning, de-icing, and cooling sometimes places the compressor operating point at the sharp downward slope of its efficiency curve, such that additional bleed flow for an air turbine would be more costly than at another point higher up on the curve.

Normally, the power extraction penalty is greater for the air turbine than for the engine-driven system. The air turbine drive may, therefore, show up at a disadvantage when the following conditions prevail:

a. Installed weight of the engine-driven system and the air turbine system are approximately equal.

b. The engine-driven system can be installed without frontal area increase.

Refrigeration Systems

In addition to its role in the generation of power, the small turbine and compressor is being increasingly called upon to supply cabin conditioning and general cooling requirements for tomorrow's aircraft. Sharp increases in cooling loads due to higher flight Mach numbers have multiplied many times the amount of heat removal required in order to supply coolant to personnel and equipment at suitable temperatures. Technological advancements are expected to permit significant increases in operating temperatures for aircraft equipment, but, of course, no such improvement in personnel tolerance and comfort requirements can be expected.

It would take about 250 household refrigerators to supply the equivalent cooling capacity for an aircraft now in development, and other aircraft in various stages of development would need many times more cooling capacity.

One refrigeration system that has been designed (Fig. 1) extracts high-pressure air from the jet engine, partially cools the air by passing it through a ram-air heat exchanger, and expands the air through an expansion turbine to obtain required coolant temperature. Control of system discharge temperature is obtained by bypassing the heat exchanger.

Turbine energy is removed by loading the turbine with a compressor, which can be utilized to induce heat exchanger flow at low airplane velocities when the ram air may be otherwise inadequate.

Movement of Fluids

Another important job that the small turbine wheel has been harnessed to do is the movement of fluids. This task has a most broad scope, spreading

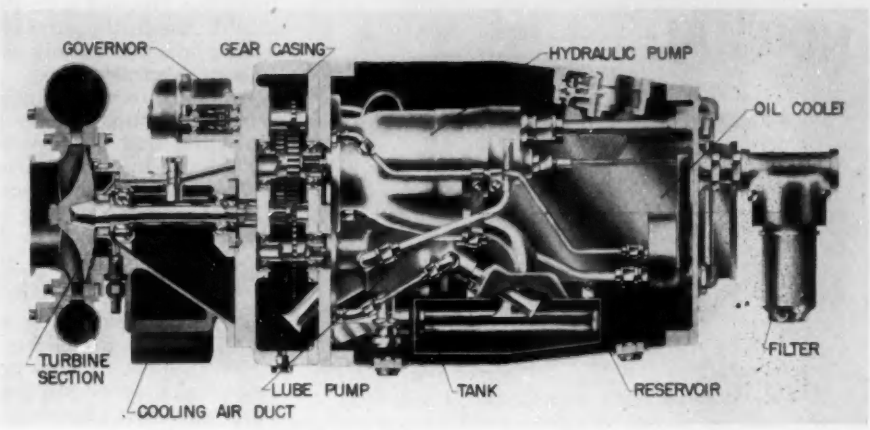


Fig. 2—Hydraulic pump utilizing small turbine

all the way from generation of hydraulic power and pumping fuel to the very specialized movement of acids and oxidizers for missile applications.

Hydraulic Power—The movement of hydraulic fluid can be accomplished pneumatically by means of a package such as the one shown in Fig. 2.

This unit utilizes a radial-inflow turbine and gearbox to drive a 3000-psi discharge pressure variable-displacement pump having maximum output of 8 gpm. Here again, location of the air turbine package close to the hydraulic load center allows substantial weight saving in many applications.

Two operating techniques have been developed for this single air turbine unit. For services performed quite frequently in flight, such as flap and aileron actuation, control of empennage surfaces, the turbine is driven continuously. For services which are performed only infrequently—steering, opening and closing bomb-bay doors, actuation of landing gear—the turbine is shut down during the no-demand periods.

This permits the most effective means of power conservation. Engine-driven hydraulic pumps extract engine power continuously—even during periods of no load. This no-load penalty can be appreciable, especially for aircraft having long missions.

An air turbine driven hydraulic package that will permit additional conservation of engine power extraction is the next development target. A so-called "on-off" drive is being brought along, which, through the use of an accumulator, will provide a means for shutting down the air turbine while still furnishing constant control for the continuous demand services. The method used is to employ an accumulator to store hydraulic fluid under pressure. A make-up pump driven by an electric motor keeps the accumulator charged, thereby making up for system leakage and providing for small load requirements. With no load on the system, the accumulator is kept charged to 3000 psi. When accumulator pressure falls below 2800 psi, due to large system load demands, a pressure regulator automatically starts the air turbine to supply the load and to recharge the accumulator.

For an application studied, it was found that the air turbine would have to be operated for only about 5% of the total mission time. As shown in Fig. 3, the "on-off" package will accordingly allow a substantial fuel weight saving by virtue of decreased power extraction. For example, as shown in Fig. 3, for a 5-hr typical mission, the "on-off" unit will save 48 lb compared to the continuous unit.

Fuel Pumping—Pumping afterburner fuel is another area where the turbine drive is racking up an impressive record.

The afterburner fuel pump, combines low-pressure boost, vapor separator and a high-pressure pump in a single turbine-driven package, which is submerged in the fuel tank. The low-pressure boost element and vapor separator are driven by the first-stage turbine; the high-pressure pump by the second turbine stage.

This is a dual-rotor unit having only aerodynamic connection between turbine stages. The low-pressure element is driven at 8000 rpm; the high-pressure element at 25,000 rpm. The unit is capable of

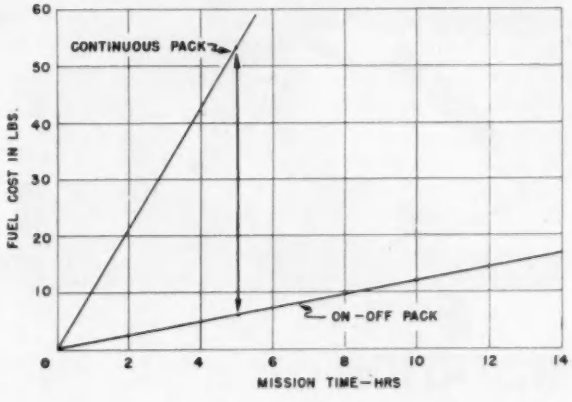


Fig. 3—Fuel cost versus mission time (typical cruise condition)

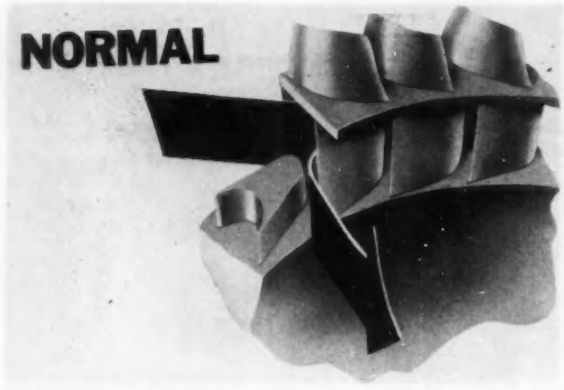


Fig. 4—Normal airflow in afterburner fuel pump

delivering fuel to the afterburner at flows up to 90 gpm and at pump discharge pressures up to 550 psi.

Perhaps the most unique feature of this pump is its method of aerodynamic overspeed protection.

As shown in Fig. 4, small tangs have been constructed on the outer edge of the first-stage turbine shroud. During the normal airflow, the air passes through the main turbine buckets as shown.

The design of these buckets is such that, as the turbine approaches overspeed, efficiency falls off rapidly and the flow chokes across the main turbine stage, as shown in Fig. 5.

At this point, the airflow tends to flow around the outside of the shroud through the extending tangs. These tangs are reversing in force direction from that of the main stage buckets, and accordingly a braking action is exerted upon the turbine wheel. Under extensive testing, this device has proved to be a most effective overspeed protector.

The compact packaging of this pump, that is, combining three pumping elements into a single unit, has enabled a 25-lb weight saving to be realized on the initial aircraft application. This weight saving was due mainly to removal of electric wiring to supply boost pumps.

An additional advantage is incurred, of course, in again having a device that can be turned on only when required. While the no-load power extraction for engine-driven afterburner pumps is not large, it does have to be reckoned with in comparison with a turbine pump having zero no-load extraction for a sizable portion of the entire mission time.

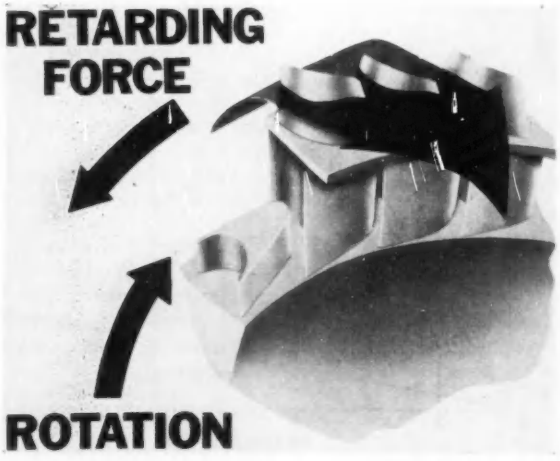


Fig. 5—Airflow during overspeed in afterburner fuel pump

Production of Torque

Principal task of a torque producer for which the small turbine wheel has been called upon is main engine starting. The advent of requirements for self-contained starting systems and the increased rotor moments of inertia of gas turbine engines, has all but eclipsed the electric starter and starter generator. In their places, we are now finding two types of turbine starting systems: pneumatic and hot-turbine, self-contained starters.

1. Pneumatic starters: The pneumatic or air turbine starter usually consists of a single-stage, radial-inflow turbine and suitable gearing mounted on the conventional engine starter pad. The starter turbine is energized by a compressed-air source, which may be ground equipment or airborne. On multi-engine aircraft, after starting one engine, the other engines can then be started by energizing the starter turbine with compressor discharge air from the engine already operating. This type of starting system is mainly being applied to bomber, cargo, and some fighter aircraft, where a self-contained starting system is not required.

2. Hot-turbine, self-contained starters: The requirement for self-contained starting systems for rapid starting has directed emphasis toward hot-turbine starters. These units are finding application in fighters, interceptors, and some bombers, where a self-contained starting system *is* required. In order to realize optimum power to weight ratio for the starting system, where a self-contained starting system is stipulated, the hot-turbine starter is indicated.

In this case, the starter drive is similar to that of the pneumatic starter, having usually a single-stage turbine and gearing, but the turbine must be designed, of course, to accept much higher temperatures. The energy source should be close to the starter drive, in some instances being mounted on the starter itself. Energy sources have fallen into three principal categories:

a. Solid propellant (cartridge).
b. Fuel and air.
c. Liquid monopropellant.

Detailed study indicates that no system has an outstanding advantage at the present stage of the art. Accordingly, we feel justified in continuing the development of all three energy systems and shall probably continue this parallel program until all systems have been evaluated by field service testing.

(Paper on which this abridgment is based is available in full in multilithograhed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Thrust Reverser Can Brake Jet Transports

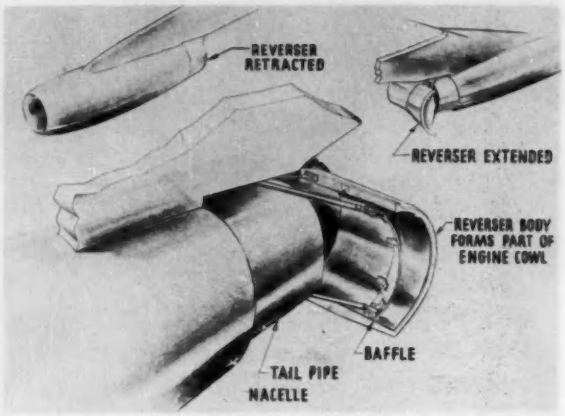


Fig. 1—Typical reverse installation for stopping jet transport on icy runway where the wheel brakes alone can't do the job, as they can on a dry runway

Joseph Sutter, Boeing Airplane Co.

Based on paper "Reverse Thrust for Jet Transports" presented at SAE National Aeronautic Meeting, New York, April 15, 1954.

CLAMSHELL-type thrust reversers appear completely practical for jet transports.

Extended, they will enable a big jet plane to stop on an icy runway in as short a distance as it can stop on a dry runway without reversal. When they're not extended, they don't affect economy.

What's more, because the jet reverser and its control are separate from the forward thrust system, the consequences of reverser failure are less severe than comparable failures of reversible propellers.

Fig. 1 shows the clamshell reverser. Fig. 2 compares its effectiveness on an icy runway with that of the reversible propeller.

The clamshell is a simple mechanical device. Its

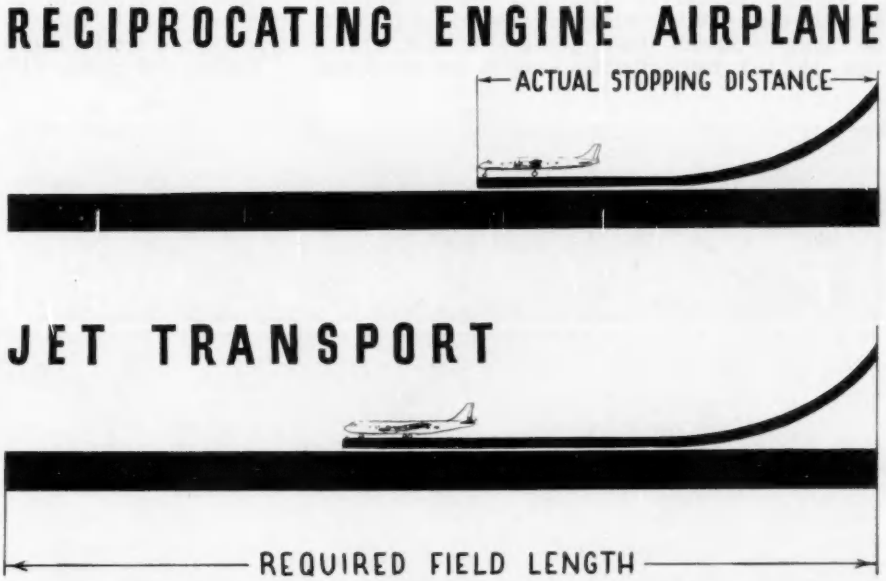


Fig. 2—Comparison of stopping distances on icy runway of current transport with reversible propellers and a proposed jet transport with jet reversal. Brakes plus four-engine thrust reversal is used on both airplanes. (Both airplanes use reversal on the ground only. The jet transport design considered incorporates aerodynamic drag brakes which provide increased drag on the approach glide comparable to that of a windmilling propeller. Jet glide path slope is about 1 to 5—which is considerably steeper than approach of current transports and is quite satisfactory)

Fig. 3—Shadowgraph of reversed jet blast showing deflection of flow. Taken in Boeing nozzle test facility

two halves swing rearward to form a deflector against which the jet exerts pressure. The deflector forces the gases to take a W-shaped path.

Obviously reverser effectiveness is proportional to the angle through which the blast is deflected. Yet this isn't the only consideration. The reversed blast must not harm the structure. Shadowgraphs like Fig. 3 prove that it does clear adjacent structure by a safe margin. But when the reverser is applied to a particular airplane, it will be necessary to make sure also that the blast does not harm more distant structure nor stir debris into air inlets.

Better Than Drag Chute

The mechanical reverser has two advantages over the drag chute as a braking device: (1) It needs no facilities outside the airplane to handle it after use. (2) It is fully effective even at the low-speed end of the ground roll, which may be the place where maximum braking is needed. (The drag chute loses effectiveness as airspeed drops.)

The clamshell reverser can be applied to a variety of turbojet installations. Fig. 1 shows it with a pod-type mounting similar to that of the Boeing 707 jet transport. It could just as well be applied to a double-pod installation, a buried-in-wing installation, or a fighter-type installation, as Fig. 4 shows.

The clamshell isn't the only possible reverser configuration, of course. Fig. 5 shows four other types Boeing has investigated, and Fig. 6 shows their performance. The clamshell style won out because of its mechanical simplicity, ease of stowage, and low installed weight. It weighs only about 200 lb per engine; design improvements may lower the figure further. Next to the clamshell style, the V-gutter type seemed most attractive.

Neither the clamshell nor the V-gutter reverser

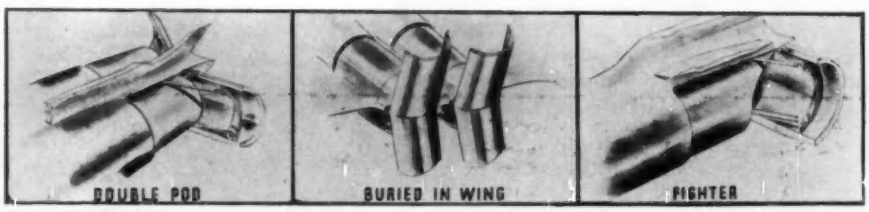


Fig. 4 (left)—Possible reverser installations in aircraft with various engine mounting configurations

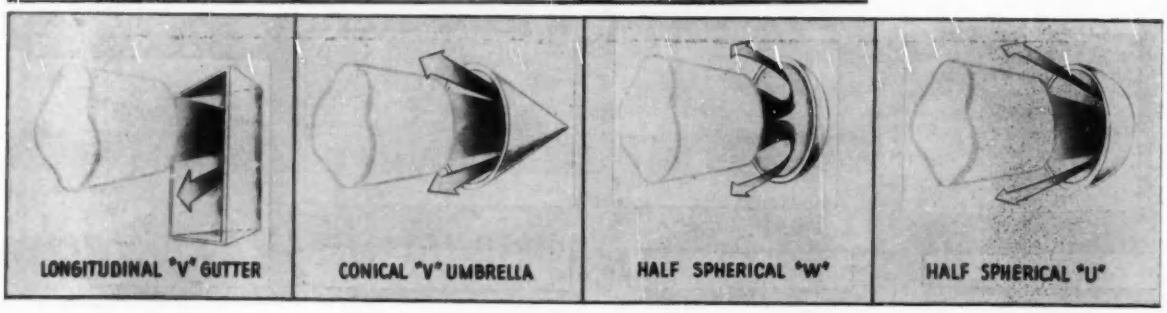


Fig. 5 (below)—Various thrust reverser configurations investigated by Boeing

affect engine characteristics during normal forward-thrust operation, since no part of the device extends into the jet blast. Scale model tests simulating the reversal show also that engine acceleration characteristics are not affected during reverse-thrust operation. Engine operating conditions are not changed because the effective tailpipe area is unchanged at normal pressure ratios corresponding to full power.

What Happens If Reverser Fails

Even the most critical jet reverser failures result in conditions only slightly worse than a simple engine failure. They are nowhere near as serious as the most serious types of reversible-propeller failures.

Table 1 lists results of a failure analysis comparing thrust-reversal and propeller-reversal failures.

In Table 1, Condition 2 for the propeller represents the most severe failure, which could occur if reversing were not incorporated. Condition 3 represents the first failure condition involving the reversing failure. It is the most critical condition. Not only is the effect on performance and control very severe, but a very high propeller over-speed results. Condition 4 represents cutting power on the engine after Condition 3. This step alleviates the difficulty only slightly, since most of the drag comes from the high induced lift of the blades in flat pitch rotating at high speed.

If the propeller passes through the flat-blade position to reverse pitch, as in Conditions 5 and 6, the situation is somewhat more tolerable.

Condition 2 for the jet reverser—that is, unwanted extension of the reverser during normal engine operation—is 1.55 times as severe as a single engine failure. But cutting power on the engine alleviates the trouble considerably, as Condition 3 shows.

Table 2 shows results of a similar failure analysis for cruise. Engine failure with the nonreversible propeller at the low-pitch stop, Condition 2, is most serious. It forces the pilot to cut cruising speed drastically to reduce windmilling drag and propeller overspeed. Condition 3 implies very high overspeed as well as a critical performance and control condition. Condition 4, in which the propeller has passed through flat pitch to reversed pitch, is still somewhat more critical than the low-pitch-stop condition.

The most severe jet-reverser failure during cruise is that where the reverser fully extends into the jet blast with power on. As in the take-off condition for the thrust-reversal jet plane, reducing power reduces the severity of the failure.

Unwanted propeller reversals are extremely rare. Unwanted jet thrust reversals will probably be even rarer. The reversible propeller uses systems which must operate continuously during normal flight to control the reverse thrust cycle. Therefore, exposure to malfunctions exists during the entire flight. The jet reverse and control, on the other hand, are separate from the basic forward thrust systems. They can be disarmed during flight, thereby minimizing exposure to malfunction.

(Paper on which this abridgment is based is available in multilithographed form from SAE Special Publications Department at 35¢ to members and 60¢ to nonmembers.)

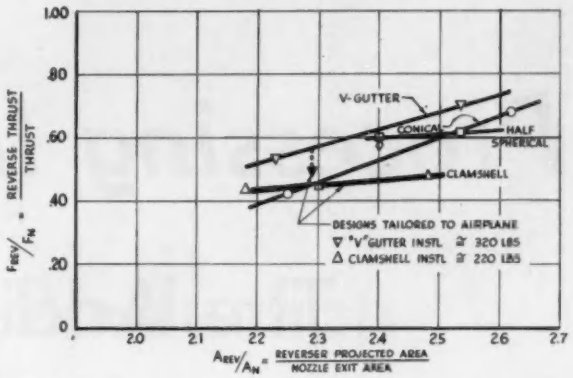


Fig. 6—Thrust reverser performance. (To stop a transport on an icy runway in the distance it will stop with brakes alone on a dry runway, takes about 40% of maximum forward thrust)

Table 1—Failure Analysis for Take-Off

Reversible Propeller		Jet Reverser	
Condition	Severity Factor	Condition	Severity Factor
1. Power Fails—Prop Feathers	1.0	1. Power Fails—Reverser Retracted	1.0
2. Power Fails—Prop to Low Pitch Stop	1.2	2. Reverser Extended—Engine Normal	1.55
3. Prop Fails—Power Normal—Prop to Flat Pitch	2.5	3. Power Off—Reverser Extended	1.05
4. Power Off—Prop to Flat Pitch	1.9		
5. Prop Fails—Power Normal—Prop to Reverse Pitch	1.4		
6. Power Off—Prop to Reverse Pitch	1.3		

Table 2—Failure Analysis for Cruise

Reversible Propeller		Jet Reverser	
Condition	Severity Factor	Condition	Severity Factor
1. Power Fails—Prop Feathers	1.0	1. Power Fails—Reverser Retracted	1.0
2. Power Fails—Prop to Low Pitch Stop	3.2	2. Reverser Extended—Engine Normal	2.1
3. Power Fails—Prop to Flat Pitch	15.0	3. Power Off—Reverser Extended	1.3
4. Prop Fails—Power Normal—Prop to Reverse Pitch	5.3		

Processing Ingenuity . . .

The Additional Ingredient

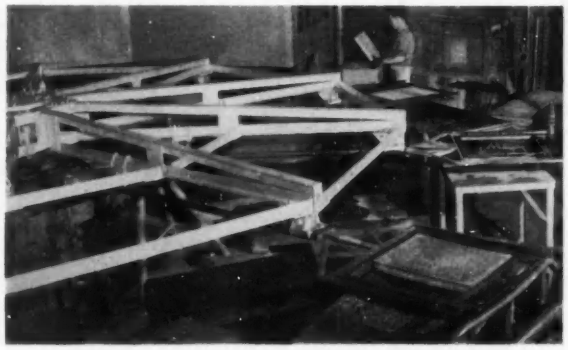


Fig. 1—It takes just one man to operate this merry-go-round type of machine which automatically solders radiator cores. One man loads the machine

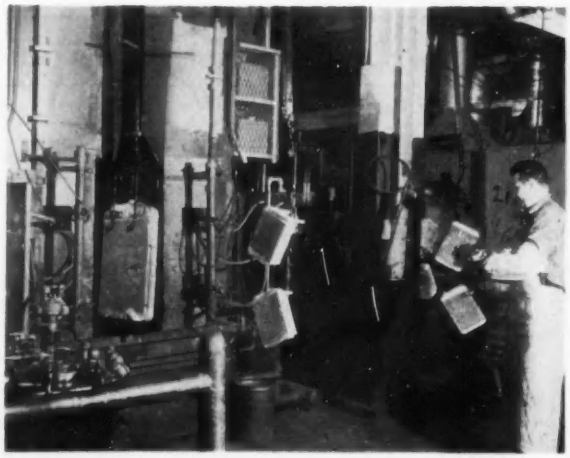


Fig. 2—This electrostatic paint-spraying installation uses only a fraction of the space, labor, and paint needed for conventional spraying

WHAT Canadian automotive plants lack in production volume they make up in many cases with unusual manufacturing ideas. Ingenious tooling and extraordinary equipment permit Canadian manufacturers to make many automotive parts at costs comparable with, or less than those, of U. S.-made parts.

Canadian manufacturing developments stem from these two circumstances:

1. Lack of space and equipment force unorthodox approaches to production problems.
2. Our tool designers, supervisors, and shop people come forth with unusually creative ideas.

In the first category we have quite a number of developments prompted by the confinement of increasing production volumes in static spaces.

• Economical Core Maker

One of these is a Bullard type automatic radiator core soldering machine. See Fig. 1. It needs only one operator to stack the core sections into a dipping frame, and a fraction of an operator to remove the completely soldered core. All operations are automatic. The equipment uses only approximately 1000 sq ft of floor space and solders all our cores.

An item falling into the same category and concerning the same part is an electrostatic paint spray booth, shown in Fig. 2. It occupies only a few square feet of space, and uses only one-half of the labor and only one-third of the paint used by conventional spraying methods.

Perhaps the near future will bring this development to where it can be applied to sheet metal parts such as hoods and fenders. It will produce a uniform application and eliminate shortcomings such as dry spray, thin paint, sags and runs due to human manipulation.

Ideas from our processing men have sometimes resulted in new and rather unique Canadian developments.

In Canadian Car Production

Charles Eder, chief inspector,
North Plant Operations, General Motors of Canada, Ltd.

Based on talk which was part of panel on "Reconciling Smaller Canadian Production to Larger U. S. Production in Automotive Field" at SAE International Production Meeting and Forum, Toronto, Oct. 29, 1953. Panel leader was D. C. Gaskin, president, Studebaker Corp. of Canada, Ltd.

• Straightener Doubles in Brass

One of these concerns a Torrington wire straightener, which was redesigned into a tube straightening and cut-off machine. (See Fig. 3.) Why? Our Canadian supplier could sell us a seamless copper tube for less than we would have paid for an imported seamed copper or brass tube of only half the wall thickness, provided we could use the domestic material in coils.

The joint efforts of our source, Anaconda, and our own designers produced this unique conversion of our machine. Our overflow tubes are straightened and cut off, as well as bundled, at a good saving.

• Taped Wire Harness Introduced

An important original development was the introduction of taping wiring harnesses in our first postwar automobile. This was done against the advice

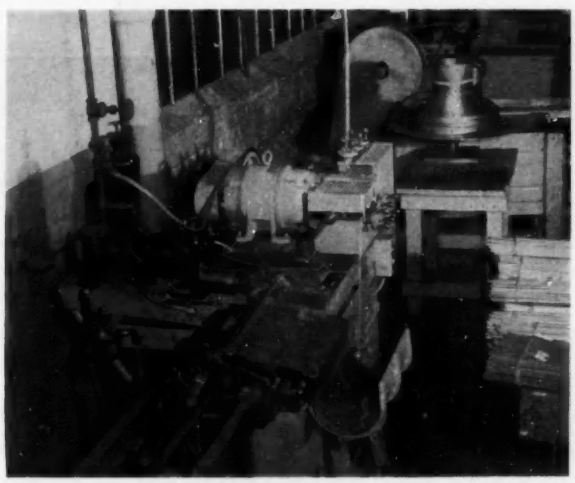


Fig. 3—This tube straightener and cut-off machine was originally a wire straightener. With it, the GMC Canadian plant can use coiled tubing and effect considerable savings

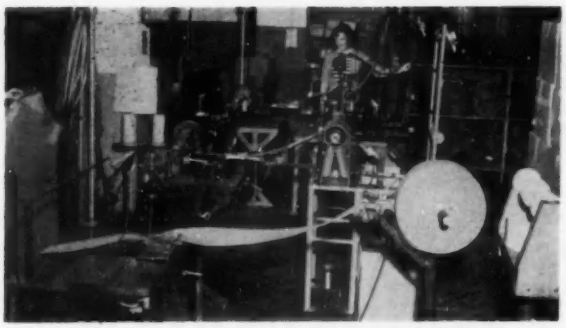


Fig. 4—One operator can run four of these airmotor-driven sewing machines used for covering wind hose

of our colleagues to the South, who maintained that braiding was simple and braiding machines were cheap. In fact, they could be bought from junk dealers for $15 to $20 apiece.

But we persisted, and ironed out all the problems arising from such a radical departure. A few years later taping was generally adopted, and has now developed into a fine art.

It was then our turn to copy our Southern friends and conveyorize our taping operations so that we could hold our own. And we have done this to a point where we are able to export complete harnesses to some of our assembly divisions in the U.S.A.

A rather unique method for covering wind-hose is used in our Cutting and Sewing Department. It's shown in Fig. 4. The sewing machine is fed by an airmotor driven drum, which has an automatic tension adjustment and a micro-switch which stops the machine if the thread breaks. A single operator can comfortably handle *four machines*.

We are quite willing to show some of these gadgets to our visitors, but only so long as they will promise that they won't tell our competitors.

Gyro finishing, a method of polishing parts for plating, was originally developed by our Process Development Section in Detroit. It was first applied in Oshawa. It presented quite a problem for some time. But we know now that, even so far as die castings are concerned, our equipment enables us to compete successfully with the best of automatic equipment in our U. S. parent divisions.

An idea from one of our employees—to replace the clips soldered on the inside of headlamp rims with easily attachable formed springs, to hold the rubber seal—was quite a departure from the old method. The new design has now been adopted by all our divisions and has earned a nice award for our employee.

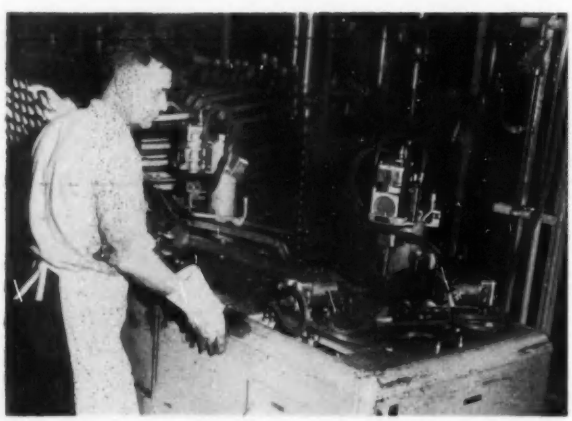


Fig. 5—Built of standard parts found around the plant, this home-made spot welder costs less than 12% of similar commercially built welding equipment. The machine is flexible, can be quickly adapted to different parts

• Home-Made Welding Machine Halves Labor

A major development by our welding engineer and his associates has started to change the thinking across the line. It will most likely influence the manufacturers of specialized welding machines.

It consists of a rectangular unit, in the shape of a large box, and can weld from eight to sixteen spots in sequence. (See Fig. 5.) It is built completely from standard capital equipment, such as motors, transformers, and parts which we keep in our stockroom—switches, timers, and valves. The surface mounts two sets of heads, which can easily be changed from year to year to accommodate changed conditions.

We are using three of these units now to weld the underbody cross-bar assembly. Our labor cost has been cut in half, and the actual cost of the complete equipment was less than 12% of that quoted by a maker of specialized welding equipment. If the design of the cross bar changes next year, our specialized machine, if used, would become obsolete.

On our simple and standardized version we just disconnect a few hoses and cables, lift the whole top, and line it up to suit the new part.

Another unit basically the same as the above three, but also adapted to deliver the part for the next operation, is used for welding cams to sash-channels. There are 14 different lengths of sash-channels; but to switch the machine from the shortest to the longest requires only 3½ sec! An added feature is a safety device which keeps the fingers of the operator away from the electrodes. We know that our machine does a *hundred pieces per hour more* than the best machine in use elsewhere.

While on the subject of welding, I should not forget that sometimes we also depend on ingenious accidents to help make our low volume production become profitable.

A recently developed detachable tip for welding electrodes, of which a quantity was accidentally made from No. 1 metal, instead of the expensive No. 2, was found to be every bit as good. Whether our new method of forging the final shape of the tip added new properties to the otherwise quite unsuitable material has as yet not been determined. But a price difference of 20% in the material price is quite a sum, when you use between 2000 and 3000

tips per month, and that particular copper costs over a dollar per pound.

Needless to say, the replacement tip itself, less than 1 in. long, is a great saving factor, when compared with a solid electrode, which sometimes has to be 6 or 7 in. long.

You might assume that everybody knows everything about stampings. And whether the metal is blanked, drawn or trimmed, all the dimensions for the necessary dies can pretty well be taken from a handbook of tables and formulas. But right now, while tooling for our '54 models, we found ways to make nice savings on some parts. On a grille bar, which is as long as the car is wide, we were able to save over a square foot of steel and eliminate some of the draw wrinkles at the same time.

A headlamp ring, which, when drawn from stainless steel needs two draws and a re-strike. When made of brass—as we do it, it needs only one draw, and saves about 6¢ per lb of material besides.

I am sure that my colleagues from Ford, Chrysler and Studebaker could continue to relate quite a number of instances where extraordinary pressures are applied to the resources of a process engineer to make him produce parts economically at our comparatively low volumes.

We occasionally succeed in attaching a "Made in Canada" label to some difficult part. But there are many cases where, no matter how hard and how often we try, we don't seem to be able to make the grade.

For instance, take door hinges. Our yearly needs are about three-quarters of a million pieces. No Canadian supplier to date has been able to afford the essential special equipment, which might cost nearly as much per hinge as we pay for a duty-free imported hinge now.

Other items are sill or scuff plates. All the attempts made to date to find somebody, not only with the ingenuity but also with a lot of "guts," to etch or stamp the required pattern on these plates, have failed. That's because a volume of 300,000 to 400,000 pieces, is still not enough to pay for the tooling in a single year.

I know that these scuff-plates have not changed in years. And nobody, outside of the Styling Engineer, has ever paid much attention to them. But if somebody told us today that we could make the plates the same, or practically the same, for two or three years, I am convinced that we could start tooling up for them tomorrow.

Door pad binding strips and trim panel mouldings cannot be made in Canada because no one has the costly equipment needed to weld nails on their backs at certain intervals.

The situation becomes more difficult if we have to add to a high cost of tools and equipment, a license fee to the patent-holder, as in the case of spun steel pulleys.

Forging dies are the oldest and simplest form of dies. And a drop hammer today looks exactly like the first one I saw forty years ago. Yet Canadian shops find it impossible to tool up for a forging, like a steering knuckle support, and make it pay, unless someone perhaps could find a die-sinker willing to work for 75¢ per hour.

Automatic handling of stampings can easily be accomplished in the U. S. because the equipment can be used year after year with only slight modifications.

Mechanical feeders, loaders and transfers are permanently attached to the presses and other tools doing the same type of part year after year. In Canada we could never think of automatic handling. That's because each press makes several widely differing parts. On medium and small items the dies are changed almost daily. Between these stampings the similarity of the die-shoes and the tonnage are the only comparable factors.

We look across to Flint and see that the dies are set up in November and then left there until October of the following year. That's why we really consider ourselves lucky that we are at all able to make hoods and fenders for our more popular models in Canada, where we have to change all the dies from left to right hand components and vice versa, every week-end.

The ensuing storing and multiple handling, combined with the repair of unavoidable dents and scratches, are problems which sometimes bring even the most patient planner to the end of his resources.

The processing ingenuity required of the tool engineer and the designer has, in our Canadian mode of manufacturing, to be extended and go all the way down to the operator.

The American, with a production volume 15 times or 20 times greater, can afford to provide tooling and equipment which is fool-proof in every sense of the word. No matter how indifferent the operator is, he can only produce perfect parts.

We have tools which are sometimes crude and not very far away from the basic form in which they are used by a tradesman. So we must rely on the whole-hearted contribution of a percentage of craftsmanship, skill, and ingenuity from our operator.

The vast gap which exists between our respective production volumes can perhaps be illustrated by an inquiry which one of the head buyers from Chevrolet directed to our own Purchasing Agent.

He said: "Say, Eric, I've got to buy parts for a special Right Drive model. We need only 5000 of them. How do you buy 5000 pieces of anything? I've never bought so little in all my life!"

Our automotive engineers are more and more acquainting themselves with the problems of the process engineer. Perhaps before long they will not only sympathize with the tool problems of today, but keep always in mind that, two or three years from now, a few changed lines on a drafting board might cost a fortune in the shop. And they might make it difficult or impossible, especially for our Canadian manufacturer, to make his part next year or the year after.

Our severest handicap today is the standard to which buyers and process men work . . . the 12-month limit in which the tool and special equipment cost has to be amortized.

But the rate at which Canada is expanding as an industrial nation is a fair indication that her difficulties will become smaller and less important, and her independence is bound to grow in proportion.

(The full text of this report, along with that of the secretaries' reports of the seven other panels at this Production Forum, is available from SAE Special Publications Department, as SP-305. Price: $1.50 to members, $3.00 to nonmembers.)

Three Problems Challenge Manufacturing Men

THREE major areas challenge production engineers today, with a fundamental theme underlying all three.

The Three Challenges:

1. How to achieve clear communications between production men and design engineers.
2. How, when, and where (if at all) automation in all its implications and phases can best be applied.
3. How best to take advantage of coming advances in manufacturing methods and engineering materials.

The Underlying Theme:

Only by achieving close production-design relationships can the reduction of manufacturing costs (implicit in all three challenges) be realized.

All at the discussion agreed that SAE is the best-equipped organization to undertake this job. That's because it encompasses design engineers, manufacturing engineers, and materials engineers. And all three groups must work hand-in-hand to make progress on the three-way job. SAE also has the facilities (national and section meetings, technical committees, and publications) which can serve as a platform for cooperation.

The First Challenge:
Better Production-Design Communications

The increasing complexity of industry and its products requires closer liaison between designer and producer than ever before. Yet this trend away from simplicity is the very obstacle to smooth communications.

Waste could be eliminated and manufacturing costs cut if there was an understanding of each other's problems between design engineer and production man, customer and supplier.

Tolerances for Processes

Few designers truly appreciate the limitations and intricacies of common fabricating processes. They specify excessively tight tolerances on forgings, castings, and machined parts. That runs up costs.

This is understandable too, because many designers have seldom, if ever, set foot into the factory. All design engineers, and the younger ones in particular, should make a special effort to know manufacturing processes in greater detail. It will enable them to create more advanced, yet practical designs.

If production men want to improve their lot, they will have to furnish designers with guides as to the minimum limits they can expect on various type parts. These tolerance guides should cover many part types produced by a variety of processes.

And a mere statistical sampling is inadequate. To work up these data, information should be gotten from incoming receiving departments of many manufacturing companies.

A similar study could profitably be undertaken

In the Automotive Industries

1. Communications with designers

2. Use of automation

3. New methods and materials

E. D. Kemble, General Electric Co., and SAE Vice President for Production Activity

Report of a round table discussion conducted by the SAE Production Activity at its meeting in Atlantic City, New Jersey, on June 8, 1954.

on metallurgical as well as dimensional properties. Designers are hungry for information on the newer materials particularly.

Drafting Delinquencies

Failure of designers to appreciate production problems also is evidenced by the inadequacy of drawings. Current drawings are not properly dimensioned to make complex parts, and don't take into consideration newer, more complicated manufacturing methods.

Today's drawing technique doesn't show the degree of judgment possible in manufacturing and inspecting parts. What's needed is a new concept—that machining and parts handling could serve as the basis for providing locating points for dimensions and tolerances.

Example:

> Distortion is inherent to thermal treatment of a part. Untold dollars in expensive equipment and manhours are wasted in getting around this distortion and making a part conform with drawings as they're now made. The engineer responsible for the print should provide a targeting surface on the part which would be machined to a mean dimension and would meet all variations of the individual part. That targeting surface then could be the basis for all subsequent drawings . . . for machine practices, tool layout, and equipment design.

Suppliers are said to be running into dimensional difficulties with large companies as well as small ones. They would like to have the buyer's checking fixture as well as the part print. That would benefit user as well as vendor.

Beyond the Dimensions

Designers want not only a part of a given geometry, they also want certain performance properties. Instead of providing the production man with test procedures for evaluating these properties in the parts he manufactures, the designer handcuffs the shop by freezing the manufacturing process. That's particularly prevalent in the aircraft industry.

To produce a part most economically, the production man needs flexibility . . . flexibility to cope with variations in the materials he is using, to modify his existing processes to take advantage of improvements, to adopt new methods which will yield savings in time and money.

This practice of the military in particular to freeze

a part's design as well as its manufacturing processes delays delivery and boosts the price. That's often because parts can't be made with materials on hand.

Such restrictions deprive manufacturers of opportunities to create. They emphasize the policing function and tend to enforce and perpetuate traditional processes. Another fault with this "freezing process" is that it draws conclusions from a limited number of samples. Result: inadequate data may be inaccurate, may point to a process that's not the best available.

Materials review procedures is another line along which better understanding between producer and designer will bring intangible savings. These procedures are very costly and are designed to be punitive, for all practical purposes, although they attempt to reduce costs and improve reliability and quality. The materials review situation is looked upon as a symptom of something more serious. Getting to the root of the problem should alleviate the symptom.

Example:

Typical of what can happen when operating with this noose of restrictions is the situation in one airplane engine builder's plant. This company has one engine part sitting on a piece of velvet in a glass case. When asked if this was the first piece of the engine line produced, the management replied: "No. We made 1200 of these parts and this is the only perfect one—the only one that met all specifications and requirements. So we think it's as precious as a jewel."

The Second Challenge: Where Does Automation Fit In?

Production men are perturbed about the sudden surge of pressures to go to automation. We've had it for years, they argue, so it's nothing new. You don't suddenly get into it or out of it. It's all a matter of degree.

And what do people mean when they talk about automation? Is it Ford's concept of eliminating all handling, with automatic transfer and automatic routing of parts through the proper sequence of operations and machine tools? Or is it the even more advanced concept, with loop control and automatic self-correction features of an entire manufacturing process?

Only basis for going to automation equipment, or any new machinery for that matter, is that it will save money. Weighing the economics of automation equipment isn't exactly a simple job. It involves factors such as size of run, continuity of run, investment cost, design lead time, installation costs, maintenance needed, and quality control requirements.

Automation equipment must also be able to cope with the hazards of design changes. A company, no matter how big it is, cannot afford to spend half a million dollars on a machine, only to find the following year that a new engine design obsoletes the equipment.

The heavy investment in automatic machinery and its limited flexibility point up one crucial need —that of indoctrinating the design engineer with information on production. And the equally important corollary to this:

"Design engineers will have to sit down with the men who design automatic equipment and their own production men who will use it to be sure that these machines will have a useful life of three to five years or more."

Many production men see a place for automatic machinery in other than metal-cutting applications. And they feel that it needn't be limited to $500,000 equipment, forming a line 200 feet long, and producing millions of pieces. For example, there is a crying need for such automatic equipment in assembly operations.

If any hard, cold facts have been brought to light on automation, they have been buried under the profusion of words on the subject. Most agreed that they need and want lots more practical information that they can apply to their specific problems.

The Third Challenge: Exploiting New Manufacturing Methods and Materials

The engineering process seems to gravitate between three points . . . design engineering, materials engineering, and manufacturing engineering. Technical progress today is like a hot potato that's been tossed into the laps of the design engineers and production men by the materials specialists. The problem today for the manufacturing fraternity is how to handle materials like titanium, the newer plastics, and ferrous materials such as the ultra-high-strength steels.

In addition, there are new horizons in fabricating conventional materials. Chipless manufacture of metal parts is one big area . . . precision casting techniques, new forging and extrusion techniques are cases in point. Plastic dies are another area where sizable manufacturing economies may be in the offing.

And the coupling of electronic brains with machine tools represents still another prolific field of study for production men.

from the Sections

Southern California

Field Editor
W. E. Achor
May 13

MILES OF RAILROAD TRACKAGE ARE BEING ABANDONED as substitute methods and facilities are becoming available. This is what SAE's president, William Littlewood told the Section.

Rights of way are becoming **increasingly expensive,** he said. "Costs of construction of trackage and railroad facilities have mounted with all other costs, and capital investment requirements are too great in view of potential traffic to justify much basic railroad expansion.

"On the other hand, that which is available in well-established traffic routes will continue for **the indefinite future,** and is possibly susceptible to substantial improvement in both passenger convenience and speed of operation."

Littlewood said the gap between the highest speed the railroads can hope for and the lowest speeds for long range air transportation is ever widening, and the two forms of transportation are **"not at all competitive** on that basis."

"It is true," he said, "that airplanes require airports and, one of the technical problems of the future is the development of maximum capacity of facilities we now have.

Littlewood said he believes that each of the transportation agencies has a definite place in the integrated transportation needs of modern life, and each will find its proper niche.

Littlewood was presented with memoirs from the Section—a spinning reel and a bottle of genuine **Los Angeles smog.**

The annual presentation of the **Mac Short award** also took place at the May meeting. Mel Hall, student chairman, introduced Mae Short who in turn officiated in presenting the Mac Short award. She also presented certificates to other students who presented papers at the Statler last April. This year's award winner was Stanley Adkins. His paper dealt with experiments to determine loss of shaft power caused by pump packings.

Detroit

Field Editor
W. F. Sherman
May 3

EUROPEAN COUNTRIES EXTEND POVERTY and low living standards by failing to develop to the utmost what they already have. This is the opinion of Fred C. Crawford, chairman of the board of Thompson Products, Inc.

The surprise, Crawford said, is that these countries are **not poor in resources,** scientists, research efforts, or even in capital. France has millions stored in sugar bowls. Belgium invests its money in American stocks, and England invests its wealth outside its own island. Another big surprise for an American is the **European business viewpoint** that it is free because it has the "freedom" to set up cartels.

Economic tradition and political backgrounds are among the forces which for 2,000 years have built up handicaps to economic progress in Europe, he said. He cited examples in the French agricultural system which uses **medieval techniques** to keep 51 per cent of the population on 10-acre farms—and with no tenant farmer allowed to have two plots adjoining.

Europe builds automobiles to conform to such limitations as horsepower taxes, narrow roads, and class distinctions, instead of designing them for production and building them to sell as we do in the United States. Automobiles tend to be **symbols of**

Southern California (May 13)

From Section Cameras

Memoirs of his visit to the Section were presented to President William Littlewood (left) by Section Chairman Homer Wood. The president is shown receiving a spinning reel. He was also given a bottle of "genuine Los Angeles Smog."

Canadian (May 28)

Canada's first SAE member, R. S. McLaughlin, (left) receives a life-membership in the Society. The life-member certificate is presented to him by J. C. Armer on behalf of the Canadian Section. McLaughlin is chairman of the Board, General Motors of Canada, Ltd. He joined SAE in 1909.

Pittsburgh (April 27)

The annual student paper competition was held by the Pittsburgh Section last April. At the right is Jack Phillippi of the University of Pittsburgh, winner. John T. Herbert, Carnegie Institute of Technology, runnerup, is at the left. In the center photo is Charles T. Devlin (left), chairman of the SAE's Student Branch at the Carnegie Institute of Technology. Devlin is presenting the award plaque to Robert Varga, present chairman of the Pitt Branch.

From Section Cameras

Metropolitan (June 6)

Of the 400 members, wives, and guests who attended the Section's reception at the 1954 Annual Summer Meeting, the group shown above was snapped by the Section camera. Seated, left to right: L. J. Grunder; Mrs. C. M. Larson; Neil MacCoull, past Section chairman; Mrs. Herbert W. Best; SAE Past President Ralph R. Teetor; Mrs. Walter G. Ainsley; and Walter G. Ainsley. Standing, left to right: Dr. Alfred G. Cattaneo; Dr. C. M. Larson; S. G. Tilden, Sr., a past Section chairman; Errol J. Gay; Mrs. Paul H. Oberreutter; and Prof. Herbert W. Best.

position in Europe which accounts for the noisy, speedy sport cars and the limited-volume expensive cars which are most typical. The unwillingness of Europeans to obsolete anything or to replace it with new things is indicated by the four electrical systems, each providing a different voltage, in the city of London.

The bright spot of Europe, he said, is Germany where the people have really gone back to work. Italy is a **land of monopolies** where many of the government-owned enterprises are in red ink. An exemplification of Italian national pride, he said, is the production of racing cars which do nothing more than boost the ego and contribute nothing to the economy.

No one in Europe asks the $64 question—"What's the trick of the American economic pace?" He said that it is the increase in productivity that accounts for our leadership and added that the useful employment of time is the real **solution of economic problems.**

Pittsburgh

Field Editor
O. B. Rosstead
Apr. 27

TO PROMOTE STUDENT ACTIVITY and encourage engineering work in the automotive field, the Section held its third annual student competition. The contest was held between one student each from the University of Pittsburgh and the Carnegie Institute of Technology. Each contestant represented his group on the basis of trial within his Student Branch.

Topics presented afforded a coordinated program on **automobile front end design.**

The winner, Jack Phillippi of the University of Pittsburgh, spoke about **"Front End Aerodynamics."** His paper was a forceful commentary on the aerodynamic aspects of past, present, and proposed future passenger cars.

John T. Herbert of Carnegie Institute of Technology presented, "The Problem of **Automotive Sway** and Means of Control." His paper was considered well-planned and indicated good understanding of mechanical and engineering design features.

Canadian

Field Editor
F. G. King
May 28

CANADA's FIRST SAE MEMBER, Col. R. S. McLaughlin, received a life-time membership in the Society at this meeting. He is chairman of the board, General Motors of Canada, Ltd., Oshawa, Ontario.

McLaughlin joined SAE in 1909. He had been

instrumental in **forming the Canadian Section,** and strengthening the organizational work in the U. S. as well as in Canada.

George H. Hammond, who heads the Automobile Division for the Fiberglas Corp., Toledo, Ohio, and Charles W. Ness, of the Canadian Fiberglas Co., were on hand to give a demonstration, and talk on **Fiberglas application.**

Highlights of his talk stressed the advantages and shortcomings of the material for automotive use. Plastics, it was pointed out, do not take the place of metal, but rather do a special job of their own. In comparison, Hammond said:

"Certain advantages in the use of plastics would improve mechanical features. **Weight saving,** the equivalent of one or two persons, results in gas saving and tire saving; it would reduce collision damage and repair costs. Antinoise and other factors make it an interesting material for the modern car."

. . . At the Section Officers Get-Together Luncheon, June 9, during the Summer Meeting at Atlantic City, 43 Governing Board members, representing 13 Sections, turned the spotlight on 1955—SAE's Golden Anniversary year. Sections Committee Chairman Leonard Raymond, who presided, presented suggestions for local activities. SAE General Manager John A. C. Warner revealed overall plans for observance of the Society's fiftieth birthday. Here's the story:

Every major segment of SAE activity will participate in observing SAE's Golden Anniversary, Warner told the group. The Council, he said, is counting on the Sections and Groups to carry the Golden Anniversary to their members. The Council urges the Sections to shape programs on an overall pattern that call for meetings which bear dignity, yet are alive, alert and **forward-looking.**

The opening salute, he said, will be sounded at SAE's Golden **Anniversary Meeting,** January 10–14. All 1955 National Meetings will carry out the theme. February will mark the publication of the SAE Journal's special Golden Anniversary issue. Already scheduled are **12 outstanding articles** taking an engineering look into the future; representing the fields covered by each one of SAE's professional activities. The Technical Board, as well as other committees, are developing **appropriate projects.**

Final chapters are being written in **a printed history of SAE,** Warner revealed, noting that it will tell in a lively tempo where we are and where we have been. It even carries out the Golden Anniversary theme of "Where Do We Go from Here."

At the close of '55, Warner prophesied, "We in SAE will have experienced another dynamic year of moving ahead on all fronts. Into every phase of our work we shall have introduced **a new look** and we shall have set our sails for more of the same aggressive movement during the next fifty years."

Sections Committee Chairman Leonard Raymond, stressed how important it is that Sections and Groups provide opportunities for members to participate in **Anniversary activities.**

Answering the question "How can Sections and Groups participate?" Raymond offered the following suggestions developed by the Sections' Committee's Executive Committee:

1.—Each Section and Group in '55 should designate one meeting as a Golden Anniversary Meeting, with a forward-looking speaker on a forward-looking subject.

2.—The meeting may be a regular technical meeting, a student meeting, or possibly a ladies' night.

3.—It would be appropriate to open the meeting with a short coffee talk by the chairman, or a longtime member, on SAE and its accomplishments. (Headquarters will provide **historical highlights** which may be referred to or used.)

4.—Possibly the SAE President or his representative could attend and make a short address.

5.—The meeting would be an opportune time to present 25 and 35-year certificates—and to pay **special tribute** to the Section member of longest membership in the society.

6.—It would add prestige to the affair if chairmen of local chapters of other technical societies are invited to participate.

7.—Students and **Junior members** should have an important part in the Golden Anniversary. They might distribute the 25 and 35-year certificates. The address of the evening might be aimed at their interests.

Raymond also announced that cuts of the **prize-winning** Golden Anniversary emblem will be available from headquarters for use on Section Meeting notices and other printed matter. The emblem also will be incorporated in the design of pocket **identification cards** used in 1955. Posters of the emblem will be available **for decoration.** Plans are to make it of appropriate size for display at the front of a rostrum.

He emphasized that the Sections and Groups are by no means bound to the suggestions of the Executive Committee. The only governing rule, he said, is that the Section and Group activities be kept in harmony with **SAE objectives** and keyed to the overall theme for observance of our Anniversary.

He noted that the thinking of the Executive Committee is that the Golden Anniversary Meeting and other observances should not be a financial drain on the individual Sections and Groups or require special appropriations from the Society.

The Golden Anniversary **spirit is building up** and there is every indication that 1955 will be a great year for the Society, its Sections and Groups, he said in his closing remarks.

SAE Student News

Starts Off With a Bang!

To start off Michigan State College's Sixth Annual Engineering Exposition with a bang, the Engineering Council sponsored a micro-midget auto race. MSC's SAE Student Branch joined with four other engineering societies in setting up specifications and building cars.

Unable to assemble the proposed variable-speed pulley transmission in time for the race, the members brought the auto to the starting line with only a pulley ratio computed for top speed. After a "slipping" start, SAE's entry was far back in third place for the first lap of four around the campus. Advancing to second place for the next two laps, the entry, driven by Neil Newman, passed the leader at the start of the final lap and won easily by a 100-yd margin.

The SAE car was constructed from brazed, thin-wall, electrical conduit. The wheels were individually suspended with a ground clearance of 3 in. and the body portion was covered with doped and painted cotton cloth. The race was termed a success by the administration.

Section Meetings Schedule

Northwest—Aug. 12

Stewart Hotel—dinner 6:30 p.m., meeting 7:30 p.m. **How Do We Fly From Here**—1954 SAE President William Littlewood.

Chicago—Sept. 10

Olympia Fields Country Club. Annual "Play Day"—golf, dinner, entertainment, etc. No technical session.

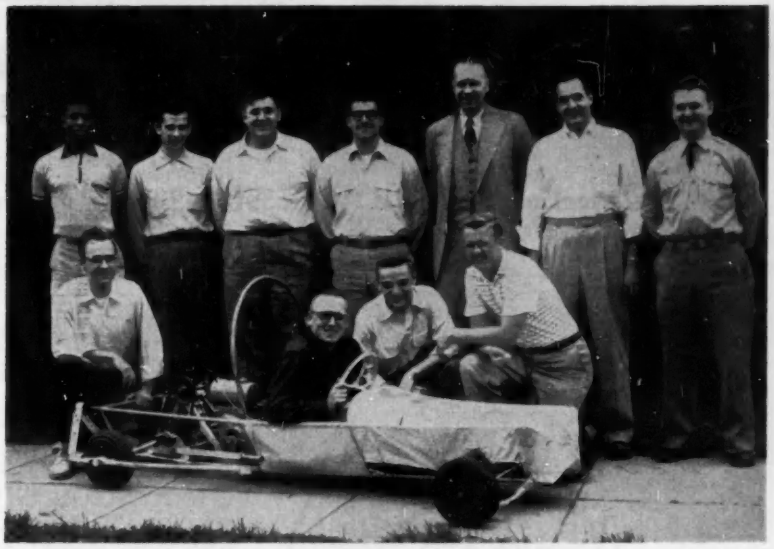
Detroit—Sept. 10-11-12

The Greenbrier White Sulphur Springs, West Virginia. Panel meetings on Design and Materials of Valve Trains—speaker to be announced; Body Styling and Color Harmony—V. M. Exner, director of styling, Chrysler Corp.

The following Sections have advised us that they will not hold any meetings during the summer months:

Buffalo
Indiana
Mid-Continent
Mid-Michigan
Milwaukee
Mohawk-Hudson
Philadelphia
Pittsburgh
Salt Lake
San Diego
Western Michigan

Something to Smile About



Michigan State Branch members have something to smile about. Their micro-midget (foreground) was winner in a race sponsored by the College's Engineering Council. The contest was part of the school's Sixth Annual Engineering Exposition.

Parks Branch Going Strong . . .

The active Student Branch at Parks College of Aeronautical Technology has made plans to visit the Chevrolet assembly plant at St. Louis. The students are even making plans to take another field trip during the summer.

The Branch has obtained new members through its open-meetings at which the entire student body is welcome. At these sessions, the benefits of SAE membership are explained and movies that are of particular interest to students are shown.

A Summing-Up at California State Poly

More than a dozen variegated meetings have been held at SAE's Branch at the California State Polytechnic College this year. One highlight of the year included a joint meeting with the ASME last January 27. Members had dinner and listened to Ray Crawford, racing enthusiast. Crawford showed films of the latest Mexican Road Race. From March 24 to 26 members took a field trip to the San Francisco industrial region. The Mac Short Memorial Award meeting of the Southern California Section took place last May, and on June 6 students enjoyed a barbecue as the last official function of the school year.

Branch at U. of Detroit Active in Campus Events

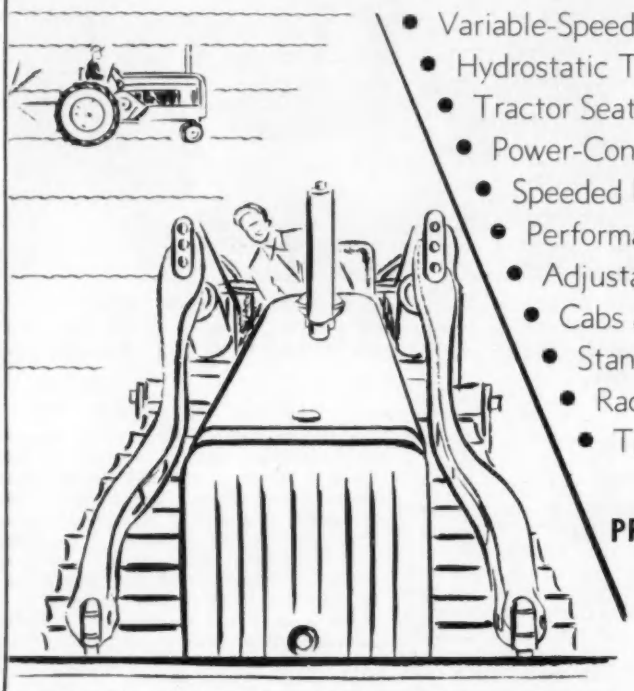
Students enrolled in the Society's Branch at the University of Detroit have been particularly active in campus events this year. These activities included a "Slide Rule Dinner," The Engineering Show and the Spring Carnival. Well-represented in all events, SAE members were especially interested in The Engineering Show. Several members ran demonstrations in the Dynamometer room in the University's automotive lab.

1954 SAE
National Tractor Meeting
and Production Forum

September 13-16, 1954

Hotel Schroeder
Milwaukee, Wisconsin

At this meeting TECHNICAL SESSIONS will highlight . . .



- Variable-Speed Drives
- Hydrostatic Transmissions
- Tractor Seat Suspensions
- Power-Controlled Tool Bars
- Speeded Up Testing of Tires
- Performance of Off-the-Road Tires
- Adjustable Speed V-Belt Drives
- Cabs and Enclosures for Earthmovers
- Standardization of Military Engines
- Radioactive Measurement of Gear Wear
- Track Testing Agricultural Machinery

PRODUCTION FORUMS will probe . . .

1. Welding
2. Inspection
3. Metal Cutting
4. Production Planning
5. Industrial Engineering
6. Indirect Manufacturing Costs
7. Gear Cutting and Heat Treating

Dinner Topic will be . . .

Industrial Uses of Atomic Energy

as seen by

Dr. Henry J. Gomburg

Michigan Memorial Phoenix Project

. . . SAE National Meetings

1954

August 16-18
National West Coast Meeting
Hotel Statler,
Los Angeles, Calif.

September 13-16
National Tractor Meeting & Production Forum
Hotel Schroeder,
Milwaukee, Wis.

October 5-9
National Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 18-20
National Transportation Meeting and Truck and Bus Engineering Display
The Sheraton-Plaza
Boston, Mass.

October 26-28
National Diesel Engine Meeting
Hotel Statler,
Cleveland, Ohio

November 4-5
National Fuels and Lubricants Meeting
The Mayo,
Tulsa, Okla.

1955

January 10-14
Golden Anniversary
Annual Meeting and Engineering Display
The Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich.

March 1-3
Golden Anniversary
Passenger Car, Body and Materials Meeting
The Sheraton-Cadillac Hotel,
Detroit, Michigan

March 14-16
Golden Anniversary
Production Meeting and Forum
Netherland Plaza,
Cincinnati, Ohio

April 18-21
Golden Anniversary Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Statler and McAlpin Hotel, New York, N. Y.

September 12-15
Golden Anniversary
Tractor Meeting and Production Forum
Hotel Schroeder
Milwaukee, Wisconsin

June 12-17
Golden Anniversary
Summer Meeting
Chalfonte-Haddon Hall,
Atlantic City, N. J.

August 15-17
Golden Anniversary
West Coast Meeting
Hotel Multnomah
Portland, Oregon

You'll Be Interested to Know . . .

NEW ACTIVITY COMMITTEE APPOINTMENTS made by the respective vice-presidents include: Aircraft Powerplant Activity—W. W. WITHEE, senior design group engineer with Consolidated Vultee Aircraft Corp. . . . Diesel Engine Activity—M. R. BENNETT, assistant manager, engineering, International Harvester Co.'s Industrial Power Division . . . Production Activity—T. L. SWANSEN, vice-president in charge of manufacturing, Ladish Co.

NEWEST SAE STUDENT BRANCH—The Pennsylvania Military College, Chester, Pa., was granted an SAE Student Branch Charter by the SAE Council at its June meeting. The Student Branch Chairman is William H. Fields, and Professor George Zanzinger is the Faculty Advisor. The number of SAE Students at PMC is 40. The PMC Student Branch Charter is the 51st.

53 Papers to be Published in 1954 SAE Transactions

The 1954 edition of SAE Transactions will be ready for publication about the end of August. It will contain 656 pages, and will be cloth bound. Price is $3 to members; $7 to public and college libraries and U. S. Government agencies; $10 to nonmembers; foreign: $3 to members, $8 to public and college libraries, $11 to nonmembers.

The papers contained in the volume are:

Turbojet-Engine Design Problems for Supersonic Flight—by J. S. Alford and E. L. Auyer

Stress Corrosion of 12% Cr Stainless Steel—by W. L. Badger

Antiknock Requirements of Passenger Cars—1951-1952—by H. W. Best, L. Raymond, and R. K. Williams

The Luster Revolution—by W. F. Bird

Tractor Hitches and Hydraulic Systems—A Tractor Designer's Viewpoint—by H. L. Brock

Measurement and Evaluation of Exhaust Noise of Over-the-Road Trucks—by D. B. Callaway

Service and Testing Observations of Fatigue Failures in Helicopter Components—by R. M. Carlson and F. D. Schnebly

Deaerating Cold-Weather Oil Systems—by F. E. Carroll, Jr.

Compression and End-Gas Temperatures from Iodine Absorption Spectra—by S. K. Chen, N. J. Beck, O. A. Uyehara, and P. S. Meyers

High-Temperature Brazing Applications—by G. D. Cremer, F. J. Filippi, and R. S. Mueller

Some Effects of Motor Oils and Additives on Engine Fuel Consumption—by C. W. Georgi

A Review of Some Contemporary British Passenger-Car Engines by C. L. Goodacre

The Postwar Car and the A-Blast . . . What Are the Odds?—(Report of the SAE-FCDA Advisory Committee)

Uncontrolled Combustion in Spark-Ignition Engines—by S. D. Heron

Deposit-Induced Ignition-Evaluation in a Laboratory Engine—by D. A. Hirschler, J. D. McCullough, and C. A. Hall

A Production Application of Structural Adhesive Bonding—by G. E. Holback and J. L. Burridge

Does the Public Benefit from Size and Weight Restrictions—by M. C. Horine

Tractor Hitches and Hydraulic Systems—An Implement Designer's Viewpoint—by B. B. Johannsen

Airplane Configurations for High-Speed Flight—by C. L. Johnson

A New Concept of Explosion Testing of Aircraft Equipment by W. K. Klose

What Happens to a Passenger When Traveling in a Car—by W. E. Lay

Hydraulic Steering in General Motors Cars—by C. W. Lincoln

Development of an Improved Automotive Diesel Combustion System—by B. Loeffler

Free-Piston and Turbine Compound Engine—Status of the Development—by A. L. London

Engine Knock as Influenced by Precombustion Reactions—by J. M. Mason, Jr., and H. E. Hesselberg

Universal Positioning Seat Track—by F. C. Matthaei, Jr.

Effects of Residual Stress on Fatigue Life of Metals—by R. L. Mattson

Effect of Shot-Peening Variables and Residual Stresses on Fatigue Life of Leaf-Spring Specimens—by R. L. Mattson and W. S. Coleman, Jr. (Report of Division XX, SAE ISTC)

Human Engineering: A New Approach To Driver Efficiency and Transport Safety—by R. A. McFarland

Locomotive Power and Performance Requirements with Special Reference to Gas Turbine Locomotives—by P. A. McGee

Effect of Lubricant Composition on Combustion-Chamber Deposits—by J. G. McNab, L. E. Moody, and N. V. Hakala

An Investigation of Preignition in Engines—by A. O. Melby, D. R. Diggs, and B. M. Sturgis

Matching the Characteristics of Helicopters and Shaft-Turbines by D. N. Meyers and Z. M. Ciolkosz

Drive Line for High-Speed Truck Engines—by W. P. Michell

Practical Application of Engine Flame Temperature Measurements—by G. H. Millar, O. A. Uyehara, and P. S. Meyers

Forty Years of Progress in Automotive Lubrication—A Look into the Future—by H. C. Mougey

Evaluation of Energy Released during Preflame Reactions—by D. R. Olson, J. T. Wentworth, and W. A. Daniel

Weather or Knock—Road Ratings and Requirement, Year-Round—by R. I. Potter, E. H. Scott, H. J. Gibson, and G. W. Stanke

The Corvette Plastic Body—by E. J. Premo

Chrysler PowerFlite Transmission—by W. R. Rodger, and A. J. Syrovy

Whither the European Automotive Diesel?—by P. H. Schweitzer and C. G. A. Rosen

Design for Fatigue—by E. H. Spaulding

The New Ford V-8 Engine—by R. Stevenson

Scavenging the Two-Stroke Engine—by C. F. Taylor and A. R. Rowgowski

Measurement and Control of Residual Stresses in Cylinder-Block Castings—by R. E. Van Deventer and F. McFarland

Report of the Tractor and Implement Safety Lighting Program by B. G. Van Zee

Torque Converter for Industrial and Commercial Vehicles—by M. J. Waclawek

The New Packard Lightweight Diesel Engines—by M. Ware, R. E. Taylor, J. Witzky

Combustion-Chamber Deposits and Octane-Number Requirement—by J. Warren

Development of the Turbo Compound Engine—by F. J. Wiegand and W. R. Eichberg

Some Effects of Fuels and Lubricants on Autoignition in Cars on the Road—by R. K. Williams and J. R. Landis

Occurrence of Preignition in Present-Day Cars in Normal Service—by R. F. Winch

Effect of Temperature on Endurance Limit and Relaxation of Spring Materials—by F. P. Zimmerli and W. P. Wood (Report of Division XX, SAE ISTC)

CAA Turbine Transport Evaluation Team Commends A-9's Air Conditioning Guide

W. W. Reaser, chairman of A-9

COMMITTEE A-9, Aircraft Air Conditioning Equipment, is entitled to add another feather to its cap. The plume comes from the CAA Turbine-Powered Transport Evaluation Team as a commendation on AIR 33, "Air Conditioning of Aircraft at High Altitudes," which A-9 prepared.

Reporting to the Civil Aeronautics Administration, the Team says:

"There was general acceptance of the view that heating, ventilating and pressurization systems are vital to the safety of flight of a high altitude aircraft (i.e., aircraft designed to operate above 25,000 feet). In this regard, certain minimum design standards are needed for the use of designers. Although of no mandatory or specification status, SAE Committee A-9 is assisting greatly in meeting this need through their work in developing Aeronautical Information Report No. 33, 'Air Conditioning of Aircraft at High Altitude.' SAE Aeronautical Recommended Practices 367, 217, and 85B have also been issued covering requirements for air conditioning of aircraft.

"Since the material being prepared and issued by SAE Committee A-9 reflects the collective experience of manufacturers and operators of aircraft equipment, it will obviously be of prime importance in the shaping of future aircraft designs insofar as air conditioning and oxygen equipment is concerned. The development of CAA policies for approval of such equipment should, therefore, begin with the fullest consideration of the industry-developed recommendations prepared by SAE Committee A-9.

"CAA should review the industry-developed recommended information and practice standards issued by SAE Committee A-9 with a view to using these as a basis for approval of air-conditioning equipment for high altitude aircraft and, if necessary, specify which particular details of this material the CAA would consider to be minimum conditions for such approval. . . ."

AIR 33 and its current revision, AIR 33A, deal with air quantity, purity, movement, pressure, temperature, humidity, and oxygen supply in aircraft flying above 25,000 and below 50,000 ft. AIR 33 was issued September 1, 1953; AIR 33A, containing more recent information, appeared June 15, 1954. Now under consideration is an addendum dealing more specifically with air conditioning of jet-powered transports.

Those serving on Committee A-9 at the time of the issuance of AIR 33 and AIR 33A were:

W. W. Reaser, Douglas, chairman; Harry C. Archer, National Air Lines; Robert L. Berner, Glenn L. Martin; Fred Boeke, North American Aviation; Randolf C. Bready, Bureau of Aeronautics; S. D. Browne, Clifford Mfg. Co.; J. H. Cantlin, Fenwal, Inc.; Alex Chudyk, Minneapolis-Honeywell; James Conners, Grumman; F. R. Ebersbach, Wright Air Development Center; John Fisher, Stewart-Warner; H. A. Geisler, Stewart-Warner; Vincent Gill, Republic; W. P. Hannan, American Airlines; J. F. Hill, Surface Combustion; G. A. Lemke, Consolidated-Vultee; W. H. Spannuth, Trans World Airlines; B. L. Messinger, Lockheed; Arthur E. Miller, Scott Aviation Corp.; J. M. Miller, Civil Aeronautics Administration; Dale Moeller, Stratos Corp.; F. T. Moore, Trans-Canada Airlines; R. A. Paselk, North American Aviation; E. J. Poitras, Fenwal, Inc.; P. C. Scofield, AiResearch; W. C. Shaw, Hamilton Standard; W. E. Spearman, American Airlines; R. F. Stapells, Canadair, Ltd.; W. F. Tice, Barber-Colman.

The committee is now working on reports on cooling of aircraft equipment and on oxygen equipment for passengers. It is a committee of the Aircraft Accessories and Equipment Division of the SAE Aeronautics Committee.

Nargi to Head New Committee

John Nargi

John Nargi, chief engineer of the B G Corp., has been appointed to head the newly formed Thermal Measurement Systems Committee (AE-2), which will hold its first meeting September 1. This committee was organized at the request of the Engine Technical Committee of AIA. It will work on standards and research problems related to thermocouples and temperature measurement systems in aircraft engines. AE-2 will function under the Engine and Accessories and Equipment Divisions of the SAE Aeronautic Committee.

Subcommittee Studies Body Cloth Test Specs

THE new Upholstering Materials Subcommittee is examing test methods used by various organizations to evaluate cloth. The Subcommittee's aim is to compile a set of standardized tests that will be useful to passenger car body men.

Samples of two cloths have already been exposed in Florida to check correlation of spectrophotometer reading with hours of exposure to natural ultraviolet light. One cloth was a green broadcloth known to fade on tone. The other was a gray broadcloth known to fade to brown. Spectrophotometer readings will be taken on each sample after each 10-hour increment of exposure over a certain minimum ultraviolet threshold. If spectrophotometer readings prove to progress in some uniform manner with exposure, the Subcommittee feels that

Continued on Page 100

About SAE

PAUL A. MILLER has been named manager of manufacturing engineering of Ford Motor Co.'s Parts and Equipment Division, at Ypsilanti, Mich. He was vice-president of the Leece-Neville Co., with which he had been associated for 20 years. Miller currently is meetings vice-chairman of the SAE Production Activity. He has been active in the SAE Cleveland Section, served as general chairman of the 1953 SAE National Production Meeting, and was an executive member of the Works Manager Group, of the Cleveland Chamber of Commerce.

Miller

Lowey

FRANCIS J. LOWEY, formerly president of the Metallic Friction Material Co., Cleveland, is now vice-president of the newly-formed Sintermet Division of American Brake Shoe Co., New York. The assets of the Metallic Friction Materials Co. have been purchased by American Brake Shoe and will be operated with present personnel as part of the Sintermet Division of Brake Shoe. It will supplement and expand the present powdered metal products of the Brake Shoe Co.

J. E. MARTIN, president of the Dana Corp., has announced an increase in jobs at the company's Spicer Mfg. Division, Toledo. Martin said this results from the resumption of the entire production of transfer cases for Willys civilian and military type jeeps.

ROBERT R. HUTCHISON, assistant chief engineer at GMC's Pontiac Motor Division, has retired after 31 years with the company. Hutchison joined the organization in 1923 when it was the Oakland Motor Car Co.

Hutchison

Mortenson

PAUL C. MORTENSON, formerly director of research of the Tank Division of Massey-Harris Co., Racine, Wis., is now executive engineer of the Racine Engineering Division.

WILLARD F. ROCKWELL, president and board chairman of Rockwell Mfg. Co., has been elevated to the grade of Fellow in the American Society of Mechanical Engineers.

A. L. BERGSTROM, vice-president in charge of engineering at the Timken Roller Bearing Co., Canton, Ohio, has announced plans to install six new furnaces and auxiliary equipment in the Timken Co.'s Bucyrus plant.

W. K. HOUPT has become vice-president for sales of the Wright Aeronautical Division of the Curtiss-Wright Corp., Wood-Ridge, N. J. He was previously sales manager for the division.

Houpt

Worthington

W. H. WORTHINGTON, director, engineering research, at Deere Mfg. Co.'s tractor works, Waterloo, Iowa, has been given the Cyrus Hall McCormick Gold Medal by the American Society of Agricultural Engineers for outstanding engineering achievement in the agricultural field.

S. ARTHUR C. WITTEN, formerly manager technical service, Bardahl Lubricants Ltd., Montreal, Quebec, Canada, is now employed by Bardahl of Southern California as manager of technical sales and service.

W. D. FOLLIS is now with Ford Motor Co. of Australia Ltd., Geelong, Victoria, Australia. Prior to going to Australia, Follis was general superintendent of the Ford Motor Co. of South Africa Ltd., Port Elizabeth.

ROBERT L. DOUGLAS has joined the Eastern Motor Express, Inc. of Terre Haute, Ind. He will be located in Bedford, Pa., in charge of Eastern's fleet maintenance. Douglas was formerly staff engineer with the Regular Common Carrier Conference, American Trucking Associations, Inc., Wash., D. C.

Douglas

Gardner

ROBERT GARDNER, who has been an independent consultant in fleet operations for the last year, is now staff engineer of the Regular Common Carrier Conference, American Trucking Associations, Inc., Washington, D. C.

TORE N. FRANZEN, product engineer, California Spring Co., Inc., Los Angeles, is with the Seaboard Coil Spring Division, Associated Spring Corp., Gardena, Calif.

Franzen

Cooper

EARL COOPER has been elected to the Racing Hall of Fame by the American Automobile Association. Cooper won more points in AAA championship racing than any other driver has ever achieved, and was a three-time national AAA champion.

Members . . .

L. O. ZICK is now president of Allen Electric and Equipment Co., Kalamazoo, Mich. He succeeds G. H. Allen who will continue as chairman of the board. Zick is chairman of the board, C. M. Hall Lamp Co., Detroit.

Zick

Goldberg

ALFRED GOLDBERG has joined Twentieth Century Aircraft, Inc., Burbank, Calif., as vice-president of the Maintenance and Engineering Division. He was previously director of maintenance for The Flying Tiger Line, Inc. in Burbank. He was a member of SAE's Air Transport Activity for 1953–54.

D. C. BURNHAM has joined Westinghouse Electric Corp. as vice-president, manufacturing. He was with GMC's Oldsmobile Division where he recently held the positions of manufacturing manager and assistant chief engineer. His headquarters are at the company's offices in Gateway Center, Pittsburgh, Pa.

Burnham

Hughes

H. H. HUGHES has been elected vice-president for Europe of Porter International Co., Wash., D. C. He was for many years Washington representative for The Studebaker Corp. His headquarters are in Zurich.

GEORGE G. McMANIS, previously automotive sales manager for Warner Electric Brake & Clutch Co., Beloit, Wis., has joined the Gary Steel Products Corp., Lynchburg, Va., as general sales manager.

GEORGE M. BUNN is with Kentucky Mfg. Co., Louisville, Ky., as Eastern sales representative. Bunn was formerly consultant of George M. Bunn and Associates, Norristown, Pa. He will now handle all sales matter for Kentucky Mfg. in the entire Eastern portion of the country. The company manufactures truck trailers and bodies.

Bunn

Livingstone

C. J. LIVINGSTONE has been appointed director, product application, for the domestic marketing department of the Gulf Oil Corp. He will be responsible for the development of the requirements for new products as well as the improvement of existing products for the company. He will also supervise matters involving the application of products to using equipment. He was director of product development in the product development and product engineering department of Gulf.

PAUL S. BAKER has been promoted to chief, flight test, thermodynamics and dynamics, at Republic Aviation Corp., Farmingdale, N. Y. He was development engineer for Republic.

DONALD H. PAUL has joined the Wisconsin Fittings Corp. at Oakfield, Wis., as a production engineer. He was chief engineer at the Formrite Tube Co., Two Rivers, Wis.

WALTER G. BAIN, vice-president and executive assistant, Republic Aviation Corp., Farmingdale, N. Y., has been appointed as vice-president and general manager.

Bain

vanderZee

ABRAM vanderZee, director and vice-president of the Chrysler Corp., Detroit, will now concentrate in a general executive capacity on various phases of the corporation's forward development program. He formerly held the position of vice-president in charge of sales.

JEAN SCHNEEBERGER, previously project engineer for the Diesel Division of Packard Motor Car Co., Detroit, is now export sales engineer for Nordberg Mfg. Co., Milwaukee.

CHARLES G. DOWD, formerly Research and Development Division chief of the Detroit Arsenal, has been appointed to chief engineer of the Detroit Arsenal.

Achievement . . .

WILLIAM S. COLEMAN, JR. has received the Engineering Society of Detroit's yearly award of achievement for the young engineer. Coleman, a senior research engineer in the engineering mechanics department, Research Laboratories Division of GMC, Detroit, is chairman of the Junior Activity of SAE's Detroit Section. The selection was made by a committee of the Engineering Society of Detroit under the direction of the Junior Section Awards Committee. He was selected because of his outstanding ability in his chosen profession and his service to his church and community.

Trophy Awarded to Firestone

RAYMOND C. FIRESTONE (center) receives the Edenburn Trophy as "the person connected with automobile racing deemed to have contributed the most to that sport during the year." **ARTHUR HERRINGTON** (right), chairman of the contest board, American Automobile Association, announced the award in Indianapolis. (Herrington, chairman of the board of Marmon-Herrington Co., Inc., Indianapolis, is a past-president of SAE.)

WILBUR SHAW (left), president and general manager of the Indianapolis Motor Speedway, joined in the award ceremony.

Estes, Perkins, and Beltz Advance at Oldsmobile

Metzel

HAROLD N. METZEL, Oldsmobile chief engineer, has announced that **ELLIOTT M. ESTES** is now assistant chief engineer of the Oldsmobile Division in charge of body and chassis design, and engineering standards. Estes will be succeeded as body engineer by **DONALD C. PERKINS**, formerly experimental engineer. **JOHN BELTZ**, previously engineering test supervisor, has been advanced to experimental engineer. **LOWELL A. KINTIGH** will continue as assistant chief engineer responsible for motor and transmission design, and the experimental department.

Estes

Perkins

Beltz

Kintigh

CEBURN PARKER, who was assistant superintendent, equipment, Indianapolis Railways, Inc., Indianapolis, has now formed the Parker GMC Truck Sales, Inc. He is selling GMC trucks in Indianapolis, Ind.

ROBERT B. POGUE, previously sales engineer for the American Brakeblok Division, American Brake Shoe Co. in Detroit, has been appointed consulting engineer of the Brake Shoe & Castings Division of the company.

WARREN A. BROWN, chemical engineer, assistant products application, Deep Rock Oil Corp., is now located at Tulsa, Okla. He was at Cushing, Okla.

DOUGLAS L. SCHULTZ, formerly engaged in research and development on fuels and lubricants at the petroleum laboratory of E. I. duPont de Nemours & Co., Wilmington, Del., has been promoted to automotive technologist, Petroleum Chemicals Division.

JOHN A. RYAN, formerly manager of Thompson Products, Inc., Cleveland, is with Visioneering Co., Inc., Cleveland.

JOHN M. CAMPBELL, administrative director, Research Laboratories Division, GMC, Detroit, has been elected a member of the board of directors of the American Society for Testing Materials. He has been elected for a three-year term. He was an SAE vice-president of the Fuels and Lubricants Activity, 1947.

Hart

DAVID K. HART has become chief mechanical engineer in the research laboratories of the Sharples Mfg. Corp. Hart was head of the Propulsion Division, Underwater Ordnance Department, U. S. Naval Ordnance Test Station at Pasadena, Calif., prior to joining Sharples.

WALDEMAR J. DISTLER has been promoted to assistant manager of sales operations, a new position in the New York office of the Ethyl Corp. Distler was sales engineer, account representative, for Ethyl in Dayton.

WILLIAM T. BEAVER has become plant manager of The U. S. Axle Co., Inc., Pottstown, Pa. He was formerly chief engineer, product manager, for U. S. Axle.

W. J. McCORTNEY, engineer in charge of rubber and plastics development, Chrysler Corp., Highland Park, Mich.; **FRED LYIJYNEN** of the Automotive Body Division of Chrysler; and **JOHN G. COFFIN,** assistant metallurgist, Chevrolet Motor Division, GMC, Detroit; are SAE members who took part in the Annual Plastics Conference. The conference ran concurrently with the 1954 National Plastics Exposition last June. McCortney presided over the June 10 session, Lyijynen presented his paper, "Reinforced Plastics Tooling" and Coffin "The Corvette Plastics Body" at the same session.

The following SAE members will take part in the 1955 Pacific Automotive Show to be held next February 24, 25, 26, and 27: **VICTOR C. CONDRON, JR.,** manufacturers agent, Bothell, Wash.; **L. J. HALDERMAN,** branch manager, Timken Roller Bearing Co., Los Angeles; and **RALPH C. SCHAYER,** manufacturing representative, Ralph C. Schayer, Inc., Los Angeles.

LORIN L. FERRALL has been elected assistant vice-president in the operating department of the Crucible Steel Co. of America, Pittsburgh. He was director of metallurgy. **D. I. DILWORTH, JR.,** previously assistant director of metallurgy, has now been assigned Ferrall's former duties.

White

HARRY L. WHITE has been appointed sales manager of the Autocar Division of The White Motor Co., Exton, Pa. White, a vice-president of the Autocar Sales and Service Co., was former manager of the Pittsburgh branch.

T. W. KUHN, vice-president in charge of sales for Bohn Aluminum & Brass Corp., has announced that a new sales office for the company has been opened in Rochester.

R. C. W. PETERSON, manager of Peterson Engineering Co., Toledo, has been elected treasurer of the American Society of Tool Engineers for the coming year.

WAYNE EWING, partner of Arrowsmith Tool and Die Co., Los Angeles, has been elected secretary of the American Society of Tool Engineers for the coming year.

Bucknell Honors Lester Lighton

LESTER E. LIGHTON (left), vice-president in charge of engineering at the Electric Storage Battery Co., Philadelphia, is shown being congratulated by Dr. Joseph W. Henderson, acting president and chairman of the board of trustees of Bucknell University, after receiving the honorary Doctor of Science degree. The occasion was Bucknell's 104th annual commencement in Lewisburg, Pa.

Lighton was given the degree in recognition of his "outstanding contributions to enlarging the resources of modern engineering."

Horatio Alger Winners

Hood

Lear

Sunnen

SAE members who have won the eighth annual Horatio Alger Awards are: **CLIFFORD F. HOOD,** president of U. S. Steel Corp.; **WILLIAM P. LEAR,** chairman of the board of Lear, Inc., Los Angeles; and **JOSEPH SUNNEN,** president of Sunnen Products Co., St. Louis, Mo. The purpose of the awards is "to bring public attention to . . . opportunities which exist in America today through the lives of the men chosen and to channel this to American youth demonstrating unlimited benefits afforded anyone with courage and industry. . ."

The Horatio Alger Awards Committee, which presented the honors, is a nonprofit organization that also aids scholarship funds for worthy students. It is sponsored by the American Schools and Colleges Association.

SAE Father and Son

EARL R. WILSON, SR. (right) has been an SAE Member since 1941 and is often referred to as the "father" of the Mid-Michigan Section. He helped organize the Section in 1945 as a Group and served as chairman from 1945 to 1948. (See July Journal, p. 94). In recognition of this service to the Section, he now serves as a Governing Board Member Emeritus. He has been a member of the production engineering staff at the Chevrolet manufacturing plant in Flint, Mich., for the past 32 years.

EARL R. WILSON, JR. (left) is a sales engineer for Raybestos-Manhattan, Inc., and has been an SAE member since 1949. He has just been elected treasurer of Mid-Michigan Section for the 1954–55 season.

Obituaries

RAYMOND E. PLIMPTON

Raymond E. Plimpton, 67, chief engineer of the specifications branch of the Detroit Arsenal, Center Line, Mich., died June 9.

Plimpton's primary interest was automotive engineering. He was an associate editor of "Bus Transportation" for about ten years during the 1920's. Later he was associated with The White Motor Co., Greyhound Management Corp., and The Four-Wheel Drive Auto Co. He spent several years with the U. S. Government, and was associated with the Motor Transport Corps during World War I.

Later he was with the NRA and the WPA, and during World War II he was with Army Ordnance.

Plimpton was born at Hartford, Conn. He received certificates in mechanical engineering and electrical engineering from Pratt Institute, and the elecrical engineering degree from Brooklyn Polytechnic Institute.

HARRY L. BILL

Harry L. Bill, vice-president and general manager of Greenfield Tap & Die Corp., Greenfield, Mass., died April 15. He was 72.

Bill died in Amersfoort, Holland, where he and Mrs. Bill had gone during a combined business and pleasure trip.

During World War I he was factory manager at the Government's airplane experimental Station, McCook's Field, Ohio. Later he was factory manager for Winton Co., Cleveland. Previously he had been general manager for Hayes Mfg. Co. and Metzger Motor Car Co., both in Detroit. He had also been supervisor for Chalmers Motor Co., Detroit; Standard Roller Bearing Co., Philadelphia; and Corbin Motor Vehicle Co., New Britain, Conn.

He entered industry in 1897 as a machinist's apprentice for Herrick & Cowl, New Haven. A few years later he was a model maker for Winchester Repeating Arms Co., New Haven.

Bill was a native of Hartford, Conn., and attended high school at New Haven.

PERCY A. HAYTHORNE is with P. R. Mallory & Co., Inc., at Indianapolis, as divisional chief engineer. He was chief metallurgical engineer, Douglas Aircraft Co., Tulsa Division.

ROBERT MONTGOMERY has joined The Kroger Co., Cincinnati, as director of property. Montgomery was formerly assistant to the general manager of the Houdaille-Hershey Corp., Detroit.

CLYDE A. CROWLEY is now with the Given Mfg. Co., Los Angeles, as director of the Development Engineering and Research Division. He was with Graham, Crowley & Associates, Chicago, as director of development engineering and research.

JAMES J. DUGGAN, is chief inspector for Marmon-Herrington Co., Inc., Indianapolis. He was with the Studebaker Corp., South Bend, Ind., as production liaison engineer.

Fourteen SAE members are among those serving on the Brake Subcommittee of the National Committee on Uniform Traffic Laws and Ordinances. They are: **J. RAYMOND ALMOND**, Midland Steel Products; **J. V. BASSETT**, Raybestos-Manhattan; **T. J. CARMICHAEL**, General Motors; **W.**

L. CROSS, JR., Connecticut Department of Motor Vehicles; **O. E. H. FROELICH**, Ward Baking Co.; **CAPT. WILLIAM L. GROTH**, Virginia State Police; **FRANK HUDSON**, GMC Truck & Coach; **STEPHEN JOHNSON, JR.**, Bendix-Westinghouse Automotive Air Brake Co.; **L. C. KIBBEE**, American Trucking Associations (alternate); **E. P. LAMB**, Dodge; **CARL C. SAAL**, Bureau of Public Roads; **J. L. SNEAD, JR.**, Consolidated Freightways; **NILS A. THUNSTROM**, Greyhound; and **R. K. WALTHER**, Trailmobile.

The Subcommittee is revising the brake performance requirement in Act V of the Uniform Motor Vehicle Code, using facts developed by the recently completed brake research project of the U. S. Bureau of Public Roads. **DONALD BLANCHARD**, secretary of the SAE Technical Board, is serving as secretary to the Sub-Committee.

S. A. GUNNESS, lubricating oil salesman for Deep Rock Oil Corp. in the Chicago area, has been promoted to assistant manager of the lubricating oil sales department. He will continue to maintain offices in Chicago and to service Deep Rock accounts throughout the Midwest and portions of Canada.

C. J. REESE, president of Continental Motors Corp., Detroit, has announced the expansion of Continental Motors' facilities by the activation of a New Products Division. The Division is located at 8647 Lyndon Avenue, Detroit, and is being staffed by scientific and technical personnel, and will engage in research and development projects.

DAVID GREGG has become civilian chief of the Integrated Range Mission, White Sands Proving Ground, in New Mexico. Gregg was formerly technical director of the Electro-Mechanical Laboratory at White Sands.

JERRY PAVELKA is now chief of aerodynamics for Republic Aviation, Farmingdale, N. Y. Pavelka was with the U. S. Steel Corp., Gary, Ind., as assistant industrial engineer.

JAMES E. WASEM, JR. has become technical engineer of the J-79 project of the Aircraft Gas Turbine Division of the General Electric Co., Lockland, Ohio. Prior to joining GE Wasem was fuels and lubricants research engineer for the Continental Oil Co.'s Development and Research Division, Ponca City, Okla.

F. M. AMBLER has joined the engineering department of the Brockway Motor Co. at Cortland, N. Y. He was truck engineer for Mack Mfg. Corp., Allentown, Pa. He has served on three of the SAE Brake Subcommittees, II, IV and VI.

Father of the Year

PAUL G. HOFFMAN, chairman of the board, Studebaker Corp., has been named "Father of the Year" by the National Father's Day Committee. He received his award from President Eisenhower at the White House a few days before Father's Day, last June. Hoffman was Economic Cooperation Administrator and at one time director of the Ford Foundation. He has seven children. His five sons all served during World War II.

DR. JOHN W. ENELL has been appointed director of the Management Information Service of the American Management Association. He was formerly assistant professor of industrial engineering at New York University.

ALFRED M. FISCHER, formerly field supervisor, automotive engineering department, Eastern District, National Carbon Co., has been promoted to sales manager, automotive products, Pittsburgh Division.

F. A. SAWYER has been appointed general sales manager of manufacturers' products of the U. S. Rubber Co.'s Footwear and General Products Division. He was development manager in the division, Mishawaka, Ind.

TIMOTHY W. MERRILL has become director of product research at the Vanadium Corp. of America, Cambridge, Ohio. Merrill was previously chief metallurgical engineer at Vanadium in New York. He will now direct research concerning applications of the company's prdoucts.

Students Enter Industry . . .

FORREST E. ELLIS (Tri-State '54) has joined the General Electric Co., Fort Wayne, Ind. At present he is in the company's training program.

CURTIS M. SMITH (San Diego State College '54) is now with Narmco, Inc., San Diego. Smith is a research engineer.

CARL K. KANESHIRO (Indiana Technical College '54) is in the engineering department of Kelman Electric & Mfg. Co., Los Angeles.

WOLFGANG SIMON (Purdue '54) is a junior test engineer for Pratt and Whitney Aircraft, East Hartford, Conn.

CHARLES W. HIPP, JR. (Clemson A & M College '54) is with the Tennessee Valley Authority at the Shawnee steam plant, Paducah, Ky. Hipp is a mechanical engineer-trainee.

Subcommittee Studies Body Cloth Test Specs

continued from page 93

the spectrophotometer may be a useful tool for measuring fade.

Other tests the Subcommittee is investigating include determinations of shrinkage, tear, coefficient of sliding friction, crocking, reaction to perspiration, and cleanability.

B. A. Luce of Chrysler is Subcommittee chairman. The other members are **L. J. Campbell** of Kaiser-Willys, **Otto Martens** of American Motors, **E. C. Pickard** of Ford, **R. H. Smith** of Fisher Body, and **R. D. Wysong** of Studebaker.

The group is a subcommittee of the SAE Nonmetallic Materials Committee.

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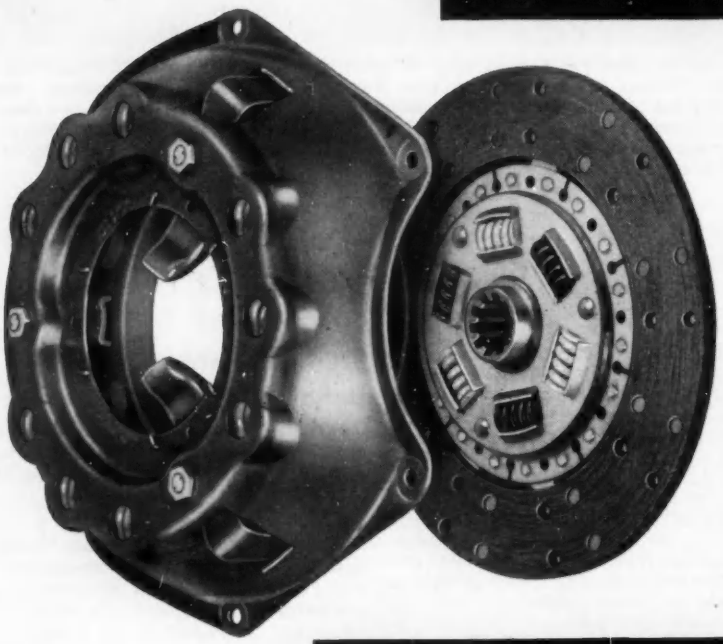

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Government Continues to Stockpile Nickel

NICKEL is not likely to become any more plentiful for steelmakers over the next few months than it has been during the last three or four years. This was the sentiment expressed at the last meeting of the Steering Committee of the SAE Iron and Steel Technical Committee.

Military usage of nickel is decreasing somewhat. But nonmilitary users probably won't benefit much as long as the foreign situation remains tense. In government circles, there is talk of building up a stockpile sufficient to take care of military requirements for a five-year period, it was reported. All nickel from new sources, such as Cuba and Oregon, is going into the stockpile.

Alloy steel capacity of the United States is now 14,000,000 tons per year. Use of 25,000,000 tons per year in case of war is foreseen by some planners. But steel mills apparently are not disposed at present to expand to that extent.

The meeting at which this information was brought out was held June 9 at Atlantic City in connection with the SAE Summer Meeting. Most of the Steering Committee's meeting was devoted to hearing reports of ISTC divisions.

SAE Approves Two Link Chain Standards

DETACHABLE LINK CHAINS—As one of the sponsors of ASA Sectional Committee B29, Transmission Chains and Sprocket Teeth, the Society has approved the following proposed American Standards:

- Malleable Iron Detachable Link Chain and Attachments.
- Steel Detachable Link Chain and Attachments.

These standards establish only those dimensions that will provide for interchangeability of the chains in use. They are not expected to restrict chain manufacturers in their overall designs.

SPINDLE NOSES—The Society has approved a proposed revision in the American Standard, "Adjustable Adapters for Multiple Spindle Drilling Heads." In addition to being revised, the standard has been expanded to cover spindle noses used with adjustable adapters.

In line with this change, the title of this AS has been changed to, "Spin-

dle Noses and Adjustable Adapters for Multiple Spindle Drilling Heads."

SAE is one of the sponsors of ASA Sectional Committee B5, Standardization of Small Tools and Machine Tool Elements, which prepared this revision.

CSMA Offers to Supply Brake Fluid Test Strips

The Chemical Specialities Manufacturers' Association has offered to arrange for a source of supply for the tinned iron and other metal test strips required to perform the corrosion test in the SAE Standard on Hydraulic Brake Fluid (SAE 70R). The proposal received the support of the Hydraulic Brake Fluid Subcommittee of the SAE Nonmetallic Materials Committee at its meeting on June 10.

The meeting was held primarily to clarify details of the testing procedures outlined in the standard, which Minnesota authorities have decreed shall be the criterion for qualification for use in that state. The Subcommittee decided to reexamine the water tolerance test, as well as to propose minor changes in other tests.

Aero Materials Specs Reviewed by Industry

DRAFTS of thirty-five SAE Aeronautical Materials Specifications are currently being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division.

Copies of all of these specifications are available for review from the SAE Aeronautical Department, 29 West 39 Street, New York 18, N. Y.

The specifications under review are:

- AMS 3330—Silicone Elastomer, Extreme Low Temperature Resistant (35-45)
- AMS 3331—Silicone Elastomer, Extreme Low Temperature Resistant (45-55)
- AMS 3332—Silicone Elastomer, Extreme Low Temperature Resistant (55-65)
- AMS 3334—Silicone Elastomer, Extreme Low Temperature Resistant (75-85)
- AMS 3340—Silicone Elastomer, Improved High Strength (600 psi) (35-45)
- AMS 3341—Silicone Elastomer, Improved High Strength (700 psi) (45-55)
- AMS 3342—Silicone Elastomer, Improved High Strength (700 psi) (55-65)
- AMS 3343—Silicone Elastomer, Improved High Strength (700 psi) (65-75)
- AMS 3344—Silicone Elastomer, Improved High Strength (700 psi) (75-85)

continued on next page

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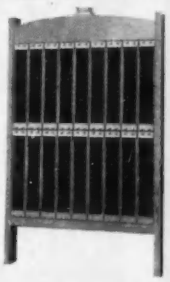

California Representative: E. E. Richter & Son, Emeryville, Calif.

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Aero Materials Specs

continued

- AMS 3351—Silicone Elastomer, Lubricating Oil and Compression Set Resistant (45-55)
- AMS 3352—Silicone Elastomer, Lubricating Oil and Compression Set Resistant (55-65)
- AMS 3353—Silicone Elastomer, Lubricating Oil and Compression Set Resistant (65-75)
- AMS 3354—Silicone Elastomer, Lubricating Oil and Compression Set Resistant (75-85)
- AMS 4260—Aluminum Alloy Castings, Precision Investment 7Si-0.3Mg (356-T6) Solution and Precipitation Treated
- AMS 4701B—Copper Wire Annealed
- AMS 4890—Copper-Beryllium Alloy Castings, Precision Investment 2Be-0.4Co-0.3Si

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- AMS 5350C—Steel Castings, Precision Investment, Corrosion Resistant 12.5Cr (SAE 60410)
- AMS 5362C—Steel Castings, Precision Investment, Corrosion and Heat Resistant, 19Cr-12Ni-(Cb + Ta)
- AMS 5375B—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-25Cr-1.8Ni-5W
- AMS 5376B—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Iron Base-21Cr-20Ni-20Co-3Mo-2.5W-1(Cb + Ta)
- AMS 5378B—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-25Cr-32Ni-5.5Mo
- AMS 5380B—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-26Cr-15Ni-6Mo
- AMS 5385C—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-27Cr-2.8Ni-5.5Mo
- AMS 5388A—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Nickel Base-16Cr-17Mo-4.5W-6Fe
- AMS 5504C—Steel Sheet and Strip, Corrosion Resistant 12.5Cr (SAE 51410)
- AMS 5521B—Steel Sheet and Strip, Corrosion and Heat Resistant 25Cr-20Ni (SAE 30310) (Deep Drawing and Spinning)
- AMS 5572B—Steel Tubing, Seamless, Corrosion and Heat Resistant 25Cr-20Ni (SAE 30310)

Aero Materials Specs

continued

- AMS 5577A—Steel Tubing, Welded, Corrosion and Heat Resistant 25Cr-20Ni (SAE 30310)

- AMS 5640F—Steel, Corrosion Resistant, 18Cr-9Ni (SAE 30303F) Free Machining

- AMS 5642C—Steel, Corrosion and Heat Resistant, 18Cr-11Ni-(Cb+Ta) Free Machining

- AMS 5643C—Steel, Corrosion Resistant, 17Cr-4Ni-4Cu

- AMS 5646D—Steel, Corrosion and Heat Resistant, 18Cr-11Ni-(Cb+Ta) (SAE 30347)

- AMS 5651C—Steel, Corrosion and Heat Resistant, 25Cr-20Ni (SAE 30310)

- AMS 7240B—Washers, Spring Lock

- AMS 7282A—Gaskets, Type XX Engine Accessory Drive, Corrosion Resistant Steel Screen Reinforced

- AMS 7472D—Bolts and Screws, Steel, Corrosion Resistant Roll Threaded

- AMS 7490B—Rings, Flash Welded, Austenitic Corrosion and Heat Resistant Steels and Alloys

- AMS 7493B—Rings, Flash Welded, Non-Austenitic Corrosion Resistant Steels

- AMS—Steel, 1.15Cr-1.95Ni-0.45Mo

- AMS 41—Aluminum Alloy Extrusions, 6.8Zn-2.75Mg-2.0Cu 0.29Cr (78S-T6)

- AMS—Titanium Alloy, 2Cr-2Fe-2Mo, Annealed 120,000 psi Yield

- AMS—Aluminum Alloy Extrusion, 1.0Mg-0.6Si-0.25Cu-0.9Cr (62S-T6)

- AMS—Aluminum Alloy Tubing, 1.0-Mg-0.6Si-0.25Cu-0.09Cr (62S-O)

- AMS—Aluminum Alloy Tubing, Hydraulic, 1.0Mg - 0.6Si - 0.25Cu - 0.9Cr (62S-T6)

- AMS—Aluminum Alloy Tubing, Hydraulic, 1.0Mg - 0.6Si - 0.25Cu - 0.09Cr (62S-T4)

- AMS—Aluminum Alloy Tubing, 1.0-Mg-0.6Si-0.25Cu-0.09Cr (62S-T6)

- AMS—Alloy Iron Castings, Sand, Corrosion and Heat Resistant 2Cr-20Ni

- AMS—Alloy Iron Castings, Ductile, Sand, Corrosion and Heat Resistant, 2Cr-20Ni

- AMS —— Steel, Corrosion and Heat Resistant, 15Cr-26Ni 1.3Mo-1.9Ti-0.3V, Solution Treated

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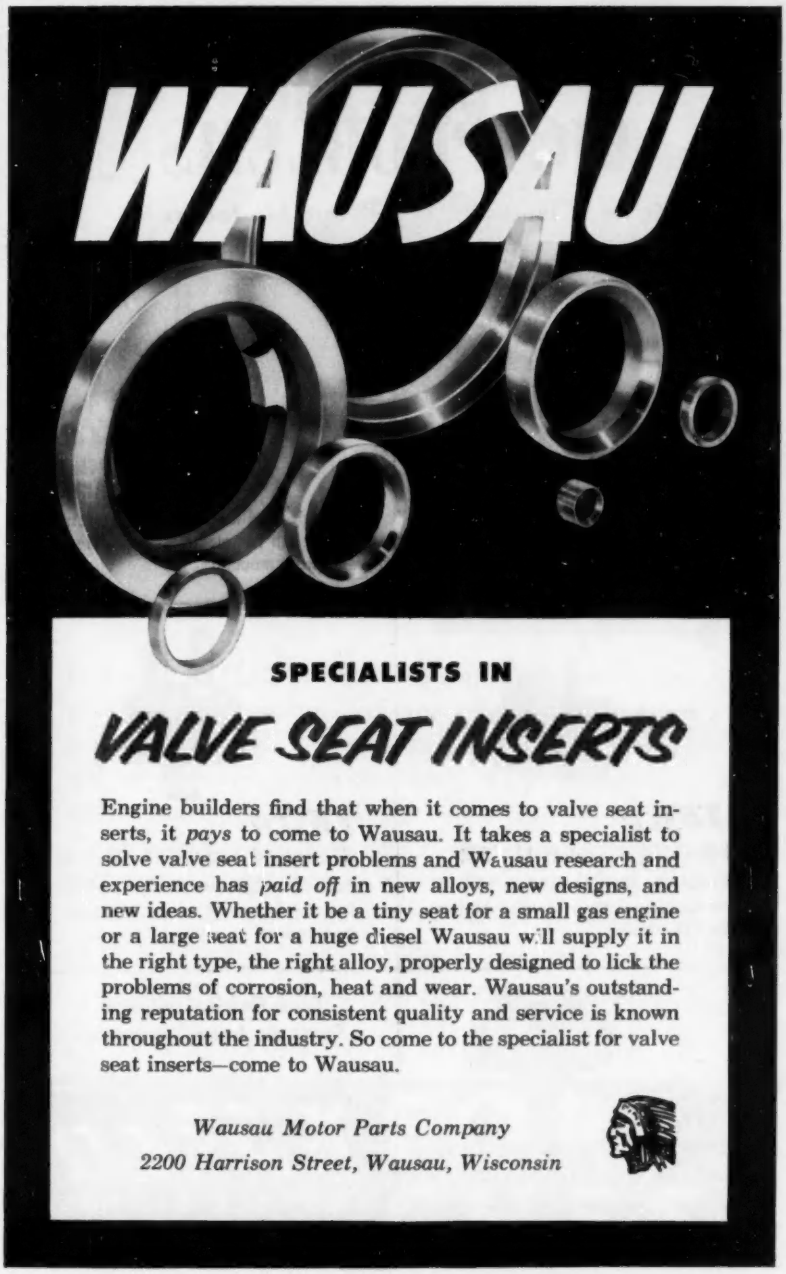
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Aero Materials Specs

continued

• AMS —— Steel Castings, Precision Investment, 0.5Cr-0.55Ni 0.2Mo (0.11-0.17C)

• AMS —— Titanium Tubing, Annealed-70,000 psi Yield

• AMS —— Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base-28Cr-5W

• AMS —— Titanium Alloy, 3Al-5Cr

11 New and 7 Revised Aeronautical Standards and Recommended Practices were released June 15, 1954. These are as follows:

• AS 56C—Level Ends—Fuel and Power Control

• AS 131A—Pads, Oil Inlet and Outlet Types I, II, & III for Airplane Connections Aircraft Engines

• AS 107B—Surface Finish

• ARP 142A—Assembling of Studs in Aluminum and Magnesium

• AS 227B—Wheels and Brakes, Minimum Requirements for Civil Aircraft Applications

• ARP 268A—Location and Actuation of Cockpit Controls for Commercial Transport Type Aircraft

• ARP 275—Aircraft Accessory Gearboxes

• AS 293—Spark Plug—Spring Contact for High Voltage

• ARP 294—Terminal, Lead, Low Voltage Igniter Plug

• ARP 295—Terminal Well, Low Voltage Igniter Plug

• ARP 296—Terminal, High Altitude, Socket Contact

• ARP 297—Terminal Well, High Altitude, Pin Contact

• ARP 298—Terminal, High Altitude, Volute Spring Contact

• AS 299—Spark Plugs, Aircraft Engine—18MM Short Reach Shielded

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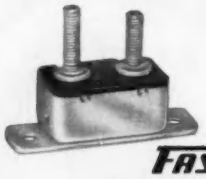

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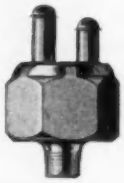

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Mexican Road Race Most Grueling of Tests

Based on paper by

J. R. GILLETTE
Ford Motor Co.

THE Mexican Pan-American Road Race is probably the toughest automotive race in the world. There are very abrasive road surfaces, straightaways where extremely high speeds are attained, and great variations in altitude. About 90% of the course is 3000 ft and more above sea level, and at one mountain point the road soars to above 10,000 ft.

The race is unique in providing the only opportunity to test cars on an actual highway nearly 2000 miles long at practically continuous full throttle. It offers an accelerated test to verify all those run previous to production release. (Paper "The 1953 Mexican Pan-American Road Race" was presented at SAE Summer Meeting, Atlantic City, June 8, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Two-Stroke Engines Gain in Dependability

Based on paper by

G. E. BUSKE
Reo Motors

AMERICAN two-stroke cycle engines have fewer parts than comparable four-stroke cycle engines and are finding wider use where low cost and light weight are essentials. Types in production today have operating ranges from idling speeds of 300 to 500 rpm up to working top speeds of 6000 rpm. Since the type of scavenging employed requires a comparatively large volume of fuel-air mixture to displace the burned gases, low idle speeds cannot be obtained by throttle position alone. In outboard usage the spark and throttle are usually synchronized so that the throttle starts to open as the spark is advanced before top dead center, the maximum advance being about 40-45 deg. Idle is obtained by retarding the spark, with closed throttle, up to 40 deg after top dead center.

Compression pressures, like lowest idle speed, vary a great deal depending upon the builder's emphasis upon low speed, high speed, or overall operation. Compression ratios may be computed on the basis of full stroke, which is not correct since compression cannot start until after the ports are closed, or from the port closing point. Pressures at cranking speed without ignition generally vary from a low of around 65 psi to a high of about 125 psi in ordinary usage. Some engines used for racing run higher.

Horsepower outputs per cubic inch vary with the performance emphasis, since an engine peaked for maximum power will usually be lacking in low speed performance. Generally the range is from around 0.5 hp per cu in. up to a maximum of about 1.50 at 8000 rpm. (Paper "General Construction—American Two Stroke Cycle Engines" was presented at SAE Metropolitan Section, New York, March 17, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

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Harvesters Require Dual Design Approach

Based on paper by

STEPHEN M. YOUNG
International Harvester of Canada, Ltd.

THERE are two basic requirements in the development of self-propelled harvesting machines—the automotive design and functional design. Since the primary function is crop processing, the automotive design is almost incidental, although essential, and is concerned with transportation to and through the crop.

These basic requirements necessitate a powerplant adequate to propel the machine at road speeds for transporting and at all field operating speeds, plus operation of the harvesting mechanism. Auxiliary motors could be used and are where absolutely necessary, but generally this only adds unnecessarily to production costs.

The harvesters must also have provision for the proper carrying of the harvested material and unloading it either into final storage or into trucks for delivery to elevators or bins. (Paper "Automotive Farm Implements" was presented at SAE Canadian Section, Toronto, Jan. 20, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

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Oil Consumption Study Confirms Previous Work

Based on paper by

L. A. McREYNOLDS
S. C. BRITTON
AND
H. T. QUIGG
Phillips Petroleum Co.

LABORATORY and road studies comparing the oil consumption of a very high V.I. SAE 10W-30 motor oil with SAE 10W and SAE 30 oils containing no V.I. improvers confirm the findings of previous investigators that oil consumption is dependent primarily upon oil viscosity measured at 300 F.

All investigators have assumed that difference in oil volatility had little effect on consumption and this assumption for oils of the low volatility type is borne out by these road and laboratory studies. (Paper "Consumption Characteristics of Multiple Viscosity Grade Motor Oils" was presented at SAE Summer Meeting, Atlantic City, June 9, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Market Changes Draw Attention to Controls

G. I. LYMAN

ALTERED business conditions resulting from the change from a seller's to a buyer's market have been putting pressure on industry to be more flexible in meeting demands. This can be done without changing the basic principles of production control, although

some modification in procedures is needed to cut red tape.

Several parts plants have master schedules built up by the production control and sales departments with approval by the general manager before implementation. Sales forecasts should be tempered by production and material control thinking, with top management resolving the differences between needs of sales and production.

Production and material control costs can be controlled and tighter reins placed on inventories by controlling high cost items (roughly 75% of total) very closely while relaxing controls and increasing inventories of low cost items. However, if inventories are to be held within reasonable limits, turn-over rates increased, and prompt service still given to the customer, the setting up of arbitrary expense goals would be unwise.

The expense of these departments related to productive effort is still the most favored method of exercising expense control, but some companies are considering relating this expense to the dollar volume of productive material and establishing a materials burden cost. The material burden would include such items as purchasing, receiving, receiving inspection cost, and the like, in addition to production and material control.

(The secretary's report on which this article is based is available in full in multilithographed form together with reports of eight other panel sessions of the SAE Chicago Production Forum, March 29, 1954. This publication, SP-306, is available from the SAE Special Publications Department. Price: $1.50 to members; $3.00 to nonmembers.)

New Beech Aircraft Improves on Model 50

Based on paper by

M. J. GORDON
Beech Aircraft Corp.

SINCE a gain in performance of the Bonanza was achieved by switching from wood to metal propellers, Beech decided to try a similar switch on the Model 50. Here again, gains were recorded in flight tests. It appeared that when engine power was increased from normal power, 240 hp at 3000 rpm, to 3400 rpm which is take-off rating and 260 hp, the airplane speed and rate of climb actually decreased instead of increasing as would be expected. Lycoming assured us this was not possible, but our flight tests had been so complete we were absolutely certain this was happening. When Lycoming tested the engine with its exhaust system of the test stand, no increase in horsepower was found to result from 3000 to 3400 rpm due to reduction in the area of the exhaust stack. When this restriction was removed, a substantial improvement in performance was measured.

The new Model B50 incorporates changes in the exhaust system, elevator down spring system, the new metal propeller, and numerous structural changes, resulting from Ground Force experience with the airplane and continued development. The craft has a gross weight of 6000 lb, yet performs better in all respects than the original

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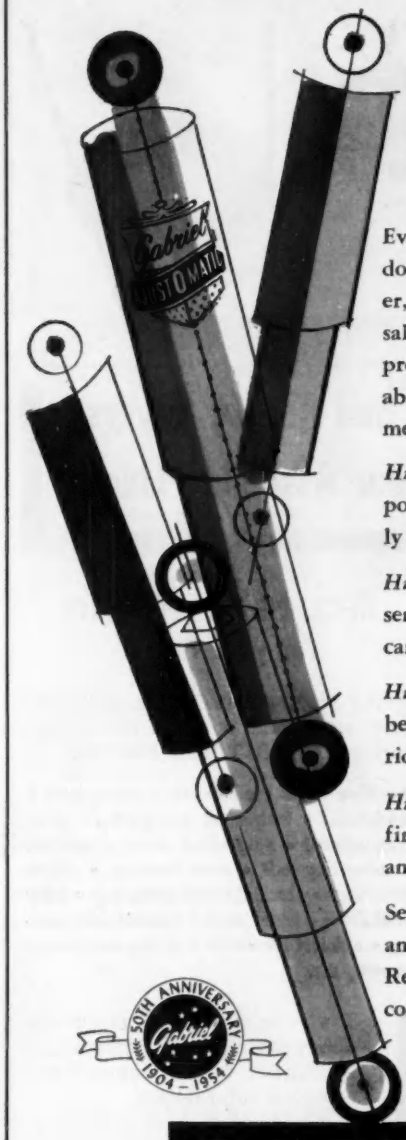

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5500 lb model. It has a high speed at 2500 ft of 205 mph and a cruise speed at 10,000 ft of 192 mph based on 65% power.

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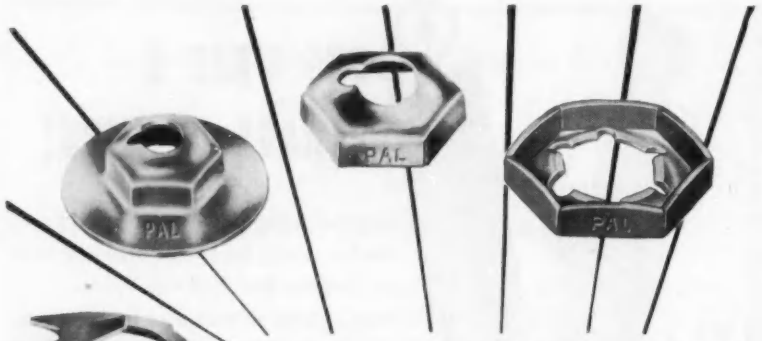

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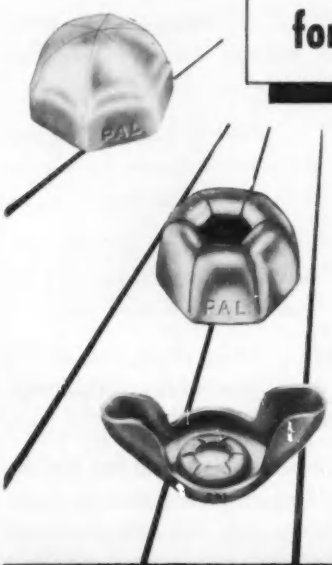

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Free Piston Engine Applied to Trucks

Excerpts from paper by

J. J. McMULLEN

Hudson Engineering Co.

ONE of the most interesting investigations being conducted by the manufacturers of free-piston gas generator-turbine combinations, Societe Industrielle Generale de Mecanique Appliquee of France, is the application of the free-piston engine to truck drive.

In addition to lowering the cost of maintenance and operation of the engine itself, a free-piston truck drive should permit a greater payload and provide a better transmission system.

One line of free-piston engine development certain to be continued, especially for uses where low specific weight and mass are required, is supercharging of the power cylinder. Outputs approaching twice the present output with little increase in severity of operation will be obtained. The weight of the powerplant will be decreased accordingly. (Paper "Performance of Free Piston Gas Generators" was presented at the SAE Milwaukee Section, April 2, 1954.)

Odd Notions Handicap Diesel Automotive Use

Based on paper by

M. C. HORINE

Mack Mfg. Co.

THE idea has gone around that diesel engine power is different from gasoline engine power. This is one of four basic misconceptions under which the diesel has had to labor in automotive applications. Actually, there are no different kinds of power. The diesel sustains its torque better at lower speeds, hence the notion. Because of this attribute, operators are encouraged to lug their engines down to speeds at which a gasoline engine would give up and stall, and thereby they do their engines a great harm.

The second misconception is that the diesel is essentially a crude-oil engine which will run on anything that will burn. Unfortunately this is partly true. It will run for a time, and after a fashion, on some bizarre fuels, including its own lubricating oil. However, for proper operation, power, reliability, and durability, the diesel fuel must be selected with as much care as that for

the gasoline engine. It will not run satisfactorily on household fuel oil or kerosene. It requires a specialized diesel fuel.

The third notion, not without some justification in the past, is that maintenance cost runs higher for the diesel than the gasoline engine. Abuse, neglect, and deficient maintenance practice will result in abnormal costs, but experience in progressive fleets has shown little if any difference between the two types of engines.

The fourth mistaken idea, that diesels are so mysterious as to require special expertness in their operation and upkeep, is rapidly disappearing. A good driver has almost nothing new to learn. A competent motor mechanic will find 90% of the work of overhaul and repair identical with the gasoline engine. Of the 10% remaining, the only really critical jobs are intimately associated with the injection system and are usually handled by specialists in the manufacturer's service organization. (Paper "Is the Automotive Diesel Here to Stay?" was presented at SAE Cincinnati Section, April 26, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

OSP Benefits Prove to be Mutual

Based on papers by

BRIG. GEN. T. P. GERRITY
U. S. Air Force

W. H. EHMANN
Republic Aviation Corp.

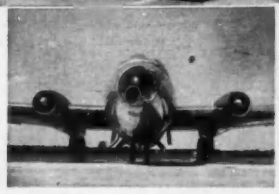
and

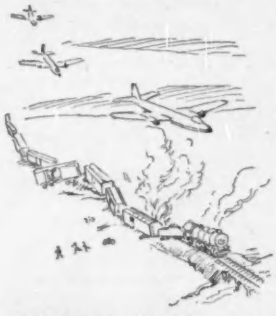
BENNO GREBELSKY
Avions Marcel Dassault

IT is not too early to assess the benefits to the U. S. Air Force and to participating Air Forces from Offshore Procurement, a vital part of the Mutual Defense Assistance Program. It has provided additional aircraft resulting in an expansion of the production base in European countries. It has assisted in the economic recovery of various nations by increasing their capacity for military production. And, by agreement with NATO countries, it has created additional orders for military aircraft and equipment from these countries.

The MDAP was a very hurried international operation which has taught

USAF... Martin B-57's ARE Alodized WITH ALODINE® No. 1200 for EXTRA PROTECTION





View of a modern "Alodine" No. 1200 installation at the Glenn L. Martin Company plant, Baltimore, Md. In these dip tanks, aluminum components of the USAF B-57 (top) are protectively treated with American Chemical Paint Company's "Alodine" No. 1200.

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us a tremendous amount. Errors were inevitable, but they have taught us important lessons. For example, we supplied various countries with electrically powered supporting equipment which could not be used. We expected 220-v, 60-cycle, three-phase power to be available only to discover the need for 42 and 50 cycle motors of various voltages. This problem was solved by supplying gasoline powered equipment.

In our American economy we tend sometimes to scrap equipment rather than be faced with uneconomical repairs. Some foreign air forces go to the other extreme. We have now learned from each other to analyze more carefully the cost of repair as compared with the cost of a new part. Our thinking has been influenced by seeing satisfactory repairs made under conditions we would have considered uneconomic. Unquestionably, the lower foreign labor rates tend to make some repairs economical which would not be in the United States.

One of the most striking examples of economic come-back is offered by France. There the aircraft industry was wiped out by war, yet today Avion Marcel Dassault is producing the Mystere IV for NATO squadrons under OSP contract. In 1945 this company had only 150,000 sq ft of factory space; today it has three plants with a combined covered area of 860,000 sq ft. And while plant was being built, several types of aircraft were developed, leading to the present model Mystere IV. In this come-back, the United States assisted by supplying machine tools under the Marshall Plan.

(Papers "OSP: Why It Came About and How It Works" by Gerrity, "MDAP Maintenance and Supply" by Ehmann, and "OSP and the Revival of the French Aircraft Industry" by Grebelsky were presented at SAE National Aeronautic Meeting, New York, April 14, 1954. They are available in multilithographed form from SAE Special Publications Department. Price: 35¢ each to members, 60¢ each to nonmembers.)

Fuel Still Influences British Engine Design

Based on paper by

C. L. GOODACRE

Clifford Motor Components, Ltd.

Complete paper will appear in 1954 SAE Transactions

"For the British engine designer," this paper says, "one of the main factors for consideration with the more popular low-priced car is that of fuel economy."

About a dozen contemporary British

passenger car engines are reviewed in great detail in this paper. In addition to relating facts and figures, the author presents designers' reasons for doing certain things in the design of their engines. Included with the commentary are 32 illustrations comprising engine sectional views and performance charts.

(Paper "A Review of Some Contemporary British Passenger Car Engines" was presented at SAE National Passenger Car Body & Materials Meeting, Detroit, March 3, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Better Practices Reduce Costly Scrap

DAVID C. GOLDBERG

Westinghouse Electric Corp.

SALT bath descaling is a potent source of hydrogen pickup and should be used with the greatest of care, especially with 12% chromium steel heat treated to high strength levels and with titanium. Proper heat treatment after salt bath descaling heat treatment does tend to drive off the contained hydrogen.

One way to avoid the problem of hydrogen pickup is to use electropolishing. The piece being electropolished is the anode and the hydrogen goes to the cathode. This process is being used by many to remove worked surface layers of metals on turbine blading and on other materials, such as 12% chromium, to improve their corrosion resistance.

When nicrobraze is applied to sheet metal parts, the tolerances between the parts should be 0.002 minimum gap with a 0.003 ± 1 as the design criterion. Good strengths have been achieved, however, with a gap as high as 0.007 in. Joint design is a must criterion in all types of brazing at all times. If it is not considered, the best brazing technique would be of no value in the end design.

Significant progress has been made in the forming of titanium; the quality of sheet has improved and so has the knowledge of handling it in the shop. To develop desired shapes, many investigators have found it necessary to apply heat as high as 900 deg. Warpage is a problem and to overcome it a new technique has been developed which calls for placing the titanium sheet between boilerplate to form a sandwich, then heating the sandwich at 1100 deg for 20 to 25 min. It is also desirable to use inert atmospheres,

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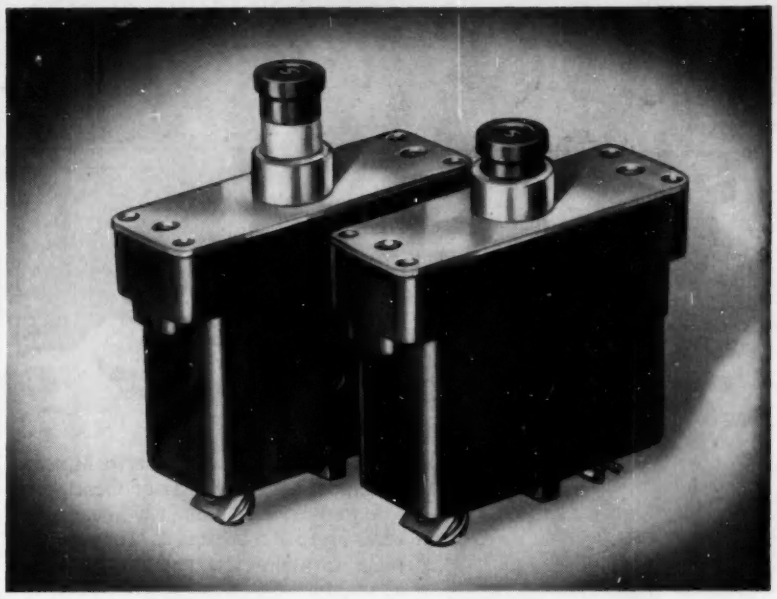

Here's a circuit breaker that gives positive circuit protection over years of operation. This design is the only push-pull, trip-free unit that can be cycled manually several thousand times with or without load without significant change in calibration.

Field reports indicate that many circuit breaker designs which require movement of the bi-metal element for unlatching change calibration even when cycled a few hundred times without load — *the D-6752 has a special latching mechanism which prevents this calibration change.*

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such as argon and helium, to prevent surface contamination.

(This article is based on the secretary's report of Panel on Metallurgical and Chemical Processing held as part of Production Forum at the SAE National Aeronautic Meeting, New York, April 12, 1954. It is available in full in multilithographed form together with the reports of the other six panels at this Production Forum, as SP-307 from SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

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North American Aviation, Inc.

Adoption Proves Merit Of Torque Converter

Based on paper by

E. W. ZINGSHEIM
and
M. M. SCHALL

Spicer Mfg. Div., Dana Corp.

SOME of the advantages of the torque converter may be peculiar to a given type of application. There are, however, very definite advantages apparent in the various applications. These are:

1—Wide range of variable ratio.

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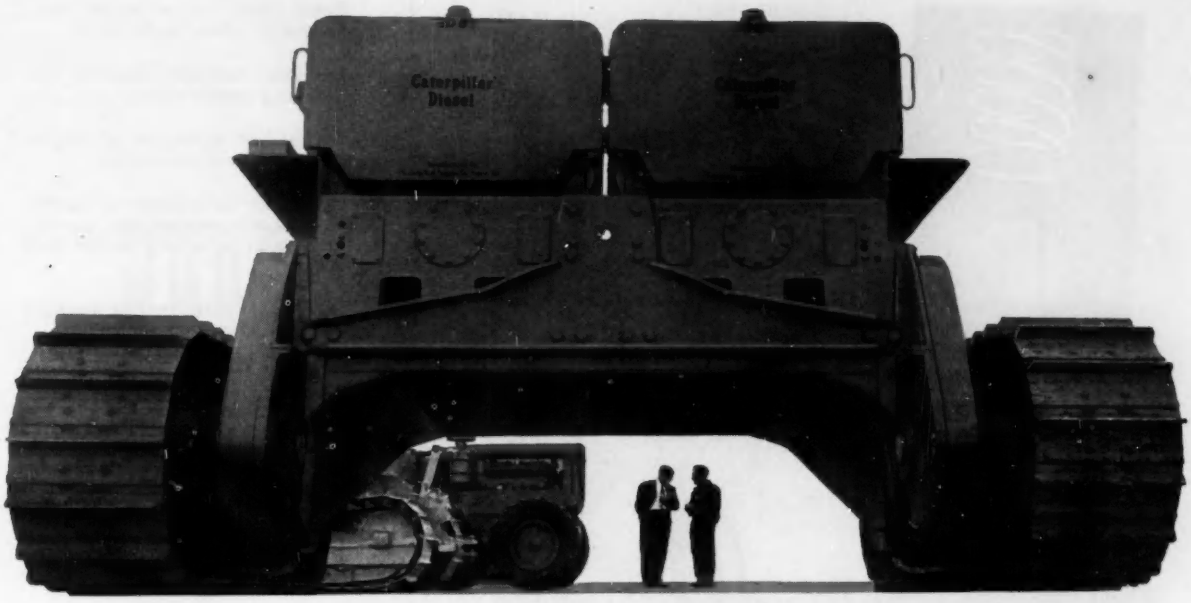
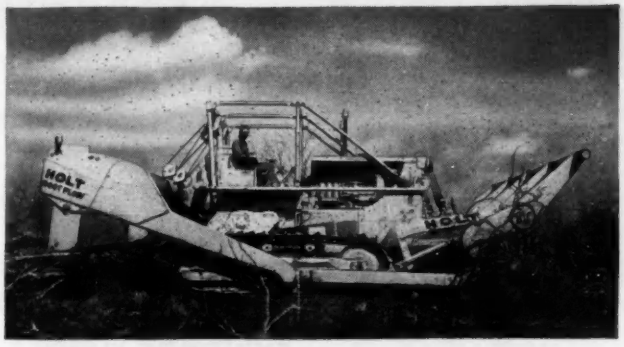
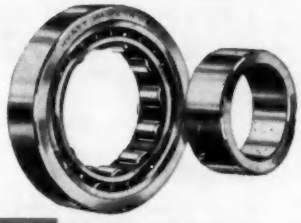


THE BIGGER THEY COME...



the greater the need for HYATT BEARINGS!



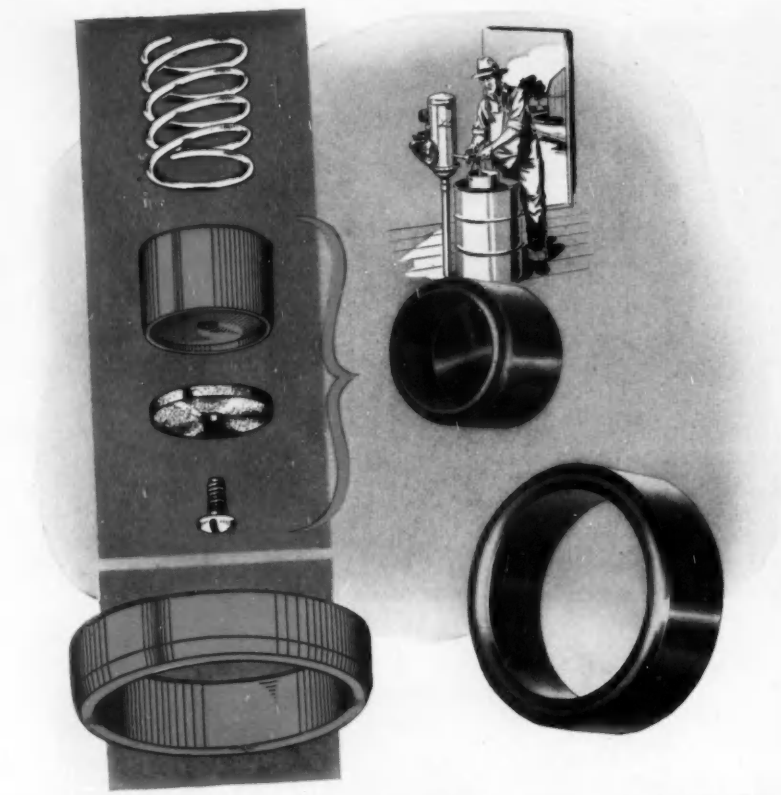
Not an atomic tank, but a "king-sized Cat"—used to clear mesquite from Texas ranches. Built by the Peterson Tractor & Equipment Company, of San Leandro, California, the giant tractor pictured above is actually two Caterpillar D-8's joined together—each with the inner track and driving mechanism removed. And in the new final drives—necessary because of increased ground clearance—the builders naturally used Hyatt Roller Bearings, the same precision bearings as those used throughout the standard tractors. As always, Hyatts were specified because they can be counted on to hold maintenance costs to a minimum while reducing friction and wear.

HYATT

STRAIGHT BARREL TAPER

ROLLER BEARINGS

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY



How G&K-INTERNATIONAL helps The Lerio Corporation cut costs by replacing machined metal parts with *molded* synthetic rubber

In the Lerio Automatic Water Pump suction is formed by two pistons operating within a small galvanized steel tank.

Discharge valve body in each piston head was formerly of brass, machined to seat a spring and retain a washer held in position with a screw. Seat in the foot valve assembly was formed from brass tubing and required three turning operations.

G&K-INTERNATIONAL engineers developed a simple cup-shaped valve body and a seating ring molded of synthetic rubber. Results: much quieter operation, and real savings in manufacturing cost and assembly time.

G&K-INTERNATIONAL is ready to work with your engineers to develop molded synthetic rubber or impregnated leather parts which may offer savings to you.

Write for G&K-INTERNATIONAL Catalog and Manual 201-A. 60 pages of up-to-date data including latest SAE and officially recommended sizes for cups, flanges, U's, V's, O-Rings — also facts on oil seals and specialties.

G&K-INTERNATIONAL *Packings*

GRATON & KNIGHT LEATHER — SYNTHETIC RUBBER

GRATON & KNIGHT COMPANY, Worcester, Massachusetts
INTERNATIONAL PACKINGS CORPORATION, Bristol, N. H.

P-4

Speed and torque ratios vary gradually while under load.

2—Excellent smooth starting and shockless acceleration.

3—Elimination of almost all engine lugging and overspeeding.

4—Operation in a more favorable speed range, increasing payload or amount of work done per unit of time.

5—Downhill hydrodynamic braking (when feature is installed).

6—Use as a dynamometer for periodic check of engine performance.

7—Elimination or minimizing of gear shifting, thus reducing mental and physical exertion of driving.

8—Reduction of maintenance cost and "down time".

9—Low drag torque at idle speeds obviating need to declutch when idling.

There are certain recognized disadvantages of the torque converter. These are:

1—Higher first cost. This may be due to added features such as a multiple speed automatic transmission behind the converter.

2—Increase in weight.

3—Generally higher fuel consumption, depending somewhat on particular application.

4—Inability to compete with gears for continuous steady operation.

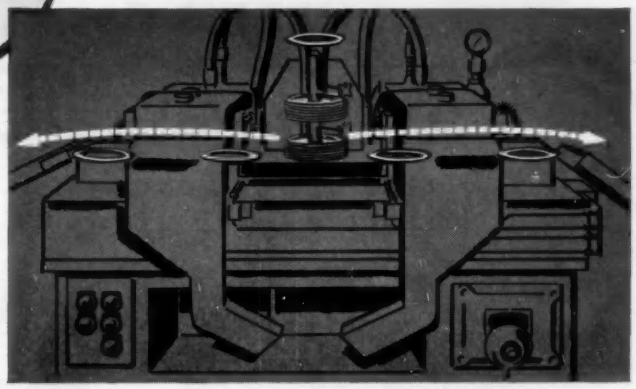
(Paper "Progress of Torque Converters" was presented at SAE Philadelphia Section, Feb. 10, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Carl A. Lindblom,
The White Motor Co.

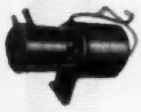
The torque converter has opened up some possible developments in engine design for the future, especially since engine and converter must now be matched and mutually supplement each other. The low-speed, low-torque, and low-efficiency parts of the engine performance curves are rendered unusable by the converter. For this reason the engine designer may now concentrate on improving the upper ranges of engine performance without having to concern himself with the sometimes conflicting low-speed requirements.

moraine engineering

...PLANNING THAT PAYS OFF



Good design ideas may never become a reality unless some means are found to translate them into finished parts *economically*. The bronze washer shown in the illustration, used in automatic transmissions, requires special contour grooving. The machining of the grooves was formerly costly and time-consuming, owing to the multiple handling required. Now . . . the parts are stacked in a machine and the grooves broached on *both* sides in *one* operation *automatically*. Parts are more uniform—produced several times as fast and at a fraction of their former cost. This is another example of Moraine "planning that pays off"—for you and your ultimate customer.



Certain cars with power brakes needed a safety feature that would maintain reserve power for braking. Moraine provides that reserve power—an electrically driven vacuum booster pump that maintains an adequate vacuum reserve.

Moraine friction materials, able to withstand great heat and friction, are widely used in Powerglide, Hydra-Matic and Dynaflow automatic transmissions. Their use has spread to other applications . . . from military vehicles to home appliances.

From the truck and bus fields came a request for a tougher bearing to withstand the many requirements of heavy-duty engines. Moraine engineering came up with the answer in the Moraine-400, the *toughest automotive engine bearing ever made!*

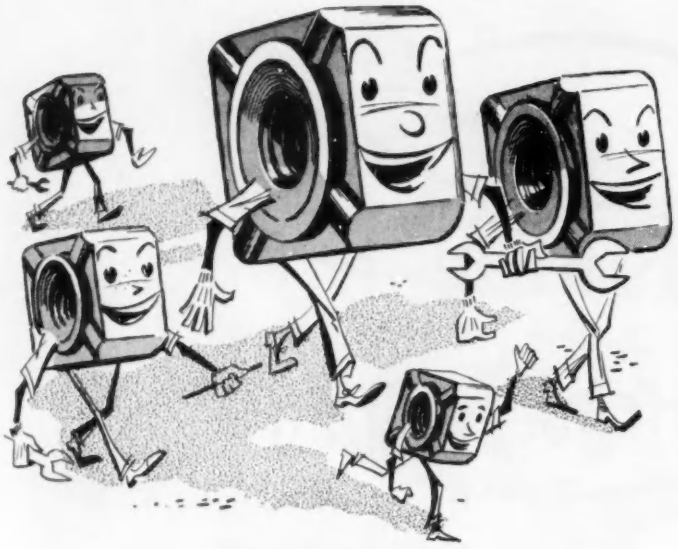
Manufacturers are learning that Moraine, through its broad metal-working experience and constructive attitude, has provided a solid foundation for the use of metal powder parts in industry. Every day, Moraine proves "It *can* be done!"

THESE PRODUCTS, TOO, ARE MORAINE

Moraine-100 engine bearings . . . Durex gasoline filters . . . Moraine porous metal parts . . . Delco hydraulic brake fluids . . . Delco master cylinders, wheel cylinders, and parts . . . Moraine conventional engine bearings and electric motor bearings.

moraine products

DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO



THERE'S A

MIDLAND

WELDING NUT

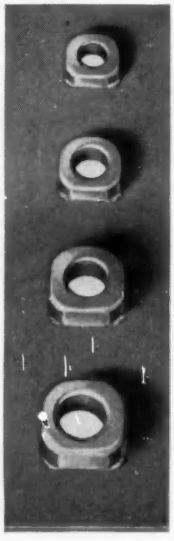
FOR EVERY SIZE JOB!

For Fabricating, Fastening, and Assembling Metal Parts . . . Midland Welding Nuts are the Answer!

No matter what your product—whether big or small—if there's metal fabricating, fastening, or assembling involved, chances are you can use Midland Welding Nuts to big advantage.

Now relied on by manufacturers the world over—and specified universally by product designers—Midland Welding Nuts will lower your assembly costs and speed up operations all along the line for you.

Write or phone for complete information.



THE MIDLAND STEEL PRODUCTS CO.

6660 Mt. Elliott Avenue • Detroit 11, Michigan

Export Department: 38 Pearl St., New York, N.Y.

Manufacturers of

AUTOMOBILE AND TRUCK FRAMES | **AIR AND VACUUM POWER BRAKES** | **AIR AND ELECTRO-PNEUMATIC DOOR CONTROLS**

New Members Qualified

These applicants qualified for admission to the Society between June 10, 1954 and July 10, 1954. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Baltimore Section

Stephen Palmer Beard (M), John E. Traise (J).

British Columbia Section

Douglas A. Court (A), Donald Andrew Duguid (J), Walter Harrington (A).

Canadian Section

William F. Beattie (A), Eric M. P. Caunce (M), J. D. Elliott (M), Barnard B. Lewis (J), J. Stanley Roberts (M), F. G. Stohge (M), Frank E. Wherley (A).

Central Illinois Section

Frank M. Chiartano (J), Roger David Hiserote (J), Gerald R. McDonald (J).

Chicago Section

Harry H. Baker (A), Donald L. Cauble (M), Thomas C. Fetterman (A), Ferdinand Fuentes (A), J. C. Laegeler (M), John Warner Layman (J), Joseph Lencki (M), Philip R. Matravers (A), Phillip E. Owen (A), Frank R. Vanderlinden (M).

Cincinnati Section

Henry Berg (A), Herman W. Richter (A), William H. Sontag (A).

Colorado Group

Forrest E. McGrath (M).

Cleveland Section

Ernest J. Balchak (M), Joseph T. Clark (J), Bruce W. Cox (J), Paul B. M. Farwell (A), Albert G. Hepp (M), William George Herridge, Jr. (M), Robert A. Leitch (M), Joseph V. Poticny (A), Donald E. Schott (J), Andrew Richard Schurger (J), Charles F. Smith (J), Carl J. Stahl (M), Carl Stefancin (M).

Dayton Section

John Robert Caldwell (J), Lawrence E. Drum (M), William E. Few (M), Harold W. Schultz (M), George Walther, Jr. (A).

New Members Qualified

continued

Detroit Section

Joseph B. Bidwell (M), Harry W. Bielicki (M), Fred Birkendahl (J), Harry L. Clark (A), Theodore E. Coffman (A), Robert Cowell (J), Claude F. Cowley (A), Arthur J. Davidson, Jr. (M), Donald C. Dickinson (J), James Frank Forster (A), Irving Frazee (M), Victor H. Geyer (J), Burck E. Grosse (J), Allan A. Harris (A), Paul A. Heber (A), Norman A. Hunstad (M), James Clinton Jones (A), Theodore R. Kermou (A), Alger G. Koepfgen (M), Zelig Landy (A), Lyndell Irving Lewis (M), Fred A. MacArthur (M), Robert D. Marcy (J), Edward O. Meisner (M), Arthur Miller (A), James Hazlitt Munger (A), Felix P. Noring (J), Gleaves Logue Omohundro (A), John S. Perrin, Jr. (J), Robert W. Rauth (J), Francis A. Sciabica (J), Thomas Scott (M), Karl M. Sims (A), W. Maynard Smith (J), Sam Sniderman (A), Glen E. Spade, Jr. (J), Thomas Clayton Spalding (J), Richard A. Teague (A), Sune E. Timour (J), Paul Albert Tracht (M), Alfred E. Taylor (J), Ting-Ming Wang (J), William Dana Wells (M), William Winn, Jr. (M).

Metropolitan Section

Alexander Bloch (J), Irvin Ritter Clark (A), William Joseph Coppoc (M), Howard L. Eckstein (A), Robert W. Forsyth (J), Nat Infurna (A), Charles E. Moser (M), Clayton S. Myers (M), Joseph A. Orsino (M), William A. Raftery (A), Edwin A. Speakman (M), John W. Thompson (M).

Mid-Michigan Section

James F. Beckwith (A), James R. Lane, Jr. (A).

Milwaukee Section

John Frank Bartholomew (J), Elmer Alfred Eigenberger (M), Orville William Lemke (A), John C. McAlvay (M), William R. Witzel (M).

Mohawk-Hudson Group

Charles W. Hurl (A).

Montreal Section

Donald F. Currie (J), A. D. Williscroft (A).

New England Section

Dixon Benjamin Sawin (M).

Northern California Section

Jack V. Harris (J).

Northwest Section

Charles Royal Evans (A).

Philadelphia Section

John Alden Glass (A), August Herman (A), James Edward Ridgway (J), John I. Wheeler (A).

St. Louis Section

James B. Davis (M).

San Diego Section

I. Dagan (A), Kermit W. Maynard (A), Floyd Frank Rechlin (M), John F. Schroepfer (M), James A. Symons (A), Robert Alvin Wedgewood (A).

Southern California Section

Herbert Gordon Blinn (M), Arthur Laudy Burton (A), Vaughn E. Connolly (A), Alexander B. Magnus, Jr. (J), Dan McCann (J), Roy N. Moore (M), Harry Allen Pelton (J), Wilfrid A. Pulver (M), Harold W. Sears (M), Burl S. Watson, Jr. (J).

Southern New England Section

J. P. Gillillan (M), Stanley L. Macklis (J), Benjamin Arron Schranze (J), Thornton Grant Woodwell (J).

Syracuse Section

Carl A. Benscoter (M).

Texas Section

Austin P. Boyd (J), William W. Hurtt (M).

Texas Gulf Coast Section

Bill Ball (J), R. A. J. Dawson (M), Milton Lenard Silberstein (A).

Twin City Section

Ernest E. Jacobs (M), Latier O. Nelscn (J).

Washington Section

Robert Frick Cecce (J).

Outside Section Territory

Thomas Hubert Dacus (A), James H. Kress (J), F. L. Napple (A), Harvey William Ritchie (J).

Foreign

Walter B. Hough, Jr. (M), Lebanon; Pierre Zenon Georges Morand (M), France; Perez Alejandro Senzacqua (A), Chile.

Twin Disc . . . *pioneer in the power linkage field* . . . offers the widest variety of power linkage for industrial equipment, with *standard* model Friction Clutches for fractional to 1325 hp, and *standard* model Fluid Drives for ¾ to 850 hp. *Applicable to all types motor or engine hook-ups,* through a wide selection of input, output combinations.

TWIN DISC

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin
Hydraulic Division, Rockford, Illinois

wider and wider use

PEARLITIC MALLEABLE CASTINGS

as engineers become aware of its many advantages

DESIGN ADAPTABILITY: Because of its good fluidity, it can be cast in thin sections and in complicated shapes.

HIGHER STRENGTH: Ultimate strengths range between 60,000 and 90,000 psi; yield strength between 40,000 and 70,000 psi.

EASILY MACHINED: Machinability index (B1112 Steel = 100) ranges between 80 and 90.

WEAR RESISTANCE: Withstands excessive wear under heavy loads at high speeds.

LOCALIZED HARDENING: Sections of the casting can be flame hardened or induction hardened before or after machining.

BEARING PROPERTIES: Good non-seizing properties in metal-to-metal contact.

FINE FINISH: Can be given a very smooth finish where desired.

You will find many applications for Pearlitic Malleable castings – particularly as a replacement for forgings, stampings and weldments – where reduced weight, less machining time, fewer assembly operations and better appearance are important production and sales considerations. A-9254

NATIONAL MALLEABLE AND STEEL CASTINGS

COMPANY

Cleveland 6, Ohio

The Nation's largest independent producer of malleable and pearlitic malleable

Applications Received

The applications for membership received between June 10, 1954 and July 10, 1954 are listed below.

Baltimore Section

Gilbert C. Bellistri, James C. Emanuel, Donald N. Liechty, James H. Rock.

Buffalo Section

Joseph D. Ryan.

Canadian Section

Guido Colm, James Kenneth Ronson.

Chicago Section

Robert A. Bell, Claud A. Fenn, Harold G. Hanlin, Philip Keith, Joseph M. Liebig.

Cincinnati Section

Bertram W. Mahoney, John G. McKinney.

Cleveland Section

Donald Everett Hilberg, Mark M. Miller, Erhart E. Sonntag, Roy Henry Springborn, Samuel Stein.

Dayton Section

Charles L. Babb, Donald Jesse Mathias, Loy D. Rhoads.

Detroit Section

Dell J. Bramble, Edward J. Chondzinski, J. Thomas Dawes, Richard R. Embry, John E. Fahlgren, Edward Hong Gong, General Doyle O. Hickey, James Gerald Hunt, Steve A. Kirol, Galen W. Lavery, H. Robert Lucas, William E. McCollough, Duncan McRae, Roy A. Oja, Samuel G. Rae, Alexander Reynolds, Elmer J. Rohn, Ralph Edward Small, Sr.

Indiana Section

Dale F. Duey, John M. Dunnewind, Dario R. Gross, John Allen Mihaloew, Howard August Peterson, John Howard Rayle.

Kansas City Section

Robert Earl DeLonge.

Forty years of leadership ...and still leading!

STROMBERG

Standard Equipment on Sweepstakes Winner—1954 Economy Run

The spectacular record of Stromberg* Carburetors in this year's Mobilgas Economy Run adds another brilliant chapter in the long history of Stromberg operating economy and performance.

Of the four cars entered in the Economy Run using Stromberg Carburetors as standard equipment, three finished first in their respective price classes and one in second place—and in the feature event—the Sweepstakes—Stromberg-equipped cars won *first* and *second* place honors.

Convincing evidence that over the years or over the miles you can't beat Stromberg Carburetors for dependable, economical operation.

*REG. U. S. PAT. OFF.

Stromberg* Carburetor | Bendix* Electric Fuel Pump | Bendix* Folo-Thru Starter Drive

ECLIPSE MACHINE DIVISION

THE NAME Bendix AVIATION CORPORATION MILLIONS TRUST

* Standard Equipment Sales: Elmira, N. Y.
* Service Sales: South Bend, Ind.
Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

VITAL PROTECTION
FOR A FEW CENTS MORE

LISLE *Magnetic* PLUGS

Small, metallic particles are constantly flaking off moving parts in engines, transmissions, and rear axles.

A strong, permanent magnet in the LISLE PLUG attracts and holds these metal particles, prevents them from circulating in lubricants. This eliminates a common cause of costly, premature wear.

Replace Ordinary Plugs with LISLE PLUGS

To Remove IRON and STEEL Particles from Oil

Sample LISLE PLUGS sent at no cost to you for testing. Simply state size and type of plug desired.

LISLE *Corporation*

CLARINDA, IOWA

Applications Received

continued

Metropolitan Section

Arthur F. Bleiweiss, Eugene F. Cramer, R. Cubicciotti, Clifford Roland Daly, Allan E. Daly, Sanford Herman, Rolf W. Lange, Robert B. Lea, Joseph Dale Smith, John Russell Sved, Miller W. Swaney, Howard Frank Tietjen, Fred L. Tunis, Jr., Harold Wanaselja.

Mid-Continent Section

Marvin Whitlock, Robert M. Tullos.

Milwaukee Section

Robert C. Brand, Frederick Norris Bulken, Aldo Celli, Elroy L. Gerschke, Wilbert Otto Gipp, Wayne E. Hartman, Jerald D. Hinke, Roy B. Jarvela, Lawrence A. Lange, Vernon G. Sommers, William J. Vickio.

Mohawk-Hudson Group

Philip H. Alspach, Carl E. Pearson.

Montreal Section

Gaétan Bienvenu, Robert B. Fullerton, John Clifton Stewart.

New England Section

Joseph J. Miliano.

Northern California Section

Herbert Victor Baak, Jr.

Oregon Section

Lloyd Alfred Doughty.

Philadelphia Section

Richard E. Crosthwait, Eugene Samuel Lubarsky, Thomas Harry Madden, William G. Mears, Paul H. Miller, Jack Robert Schaefer.

Pittsburgh Section

Frank D. Ciccarelli, Donald Stewart Fraser, Milton L. Hancock, Charles C. Mellor, Jr.

St. Louis Section

George H. Dick, Walter J. McCullough.

Eaton 2-Speed Axles

SAVE MONEY MAKE MONEY for Truck Operators

Eaton 2-Speed Axle trucks make more and quicker full-load trips—operating cost is lower, upkeep is less. Trucks last longer, earn more, are worth more on the trade-in.

More than two million Eaton Axles in trucks today!

EATON AXLE DIVISION
MANUFACTURING COMPANY
CLEVELAND, OHIO

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

MESSAGE TO AN ENGINEER THINKING ABOUT THE FUTURE— HIS FUTURE

Take a few moments now to review the progress of your career. Does your present position offer you a future that fully utilizes your creative abilities?

Compare your present assignment with the diversified, stimulating pursuits that increase the inventive challenge of Fairchild's team of qualified engineers. These men are working on engineering advances for the famous C-119 Flying Boxcar and the soon-to-be-produced C-123 Assault Transport. More than that, they are developing tomorrow's jet fighters . . . special reconnaisance aircraft . . . jet bombers and transports. The men at Fairchild know that *planned* project diversification keeps them in the forefront of the field of aerodynamics.

Gracious country living only minutes away from urban Baltimore or Washington . . . paid pension plan . . . an excellent salary with paid vacations . . . ideal working environment . . . generous health, hospitalization and life insurance . . . and the many other benefits of a progressive company add to the pleasure of working with Fairchild.

You'll be investing wisely in a secure future if you take time today to write to Walter Tydon, Chief Engineer, outlining your qualifications. Your correspondence will be kept in strict confidence, of course.

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Aircraft Division
HAGERSTOWN, MARYLAND

Applications Received

continued

San Diego Section

Roberts Roy Hoover.

Southern California Section

Philip G. Cawrey, Whitley C. Collins, Thomas A. Fling, Willard Hass, Arthur N. Heath, Lyle E. Hiatt, Frank H. Holbrook, Myron S. Jackson, Herbert M. Kurit, Craig Marks, Marvin A. Moss, Paul Weber O'Meara, George Vernon Roark, Captain Emil C. Wiener.

Southern New England Section

John F. Batter, Jr., Frank J. Bobryk, Leo George Foxwell, Alfred Gianni, Henry L. Kulper, Harold Russell Kunz, George Louis Muller, Rudolf Oeky, Robert Turton.

Syracuse Section

Charles Stephen Koegel.

Texas Section

Ray Harrison Keasler, William A. Patrick.

Texas Gulf Coast Section

Robert E. Hefner.

Twin-City Section

Marvin J. Samuelson.

Virginia Section

S. C. Walton, Sr.

Washington Section

Sumner Meiselman, Joseph S. Murphy.

Outside of Section Territory

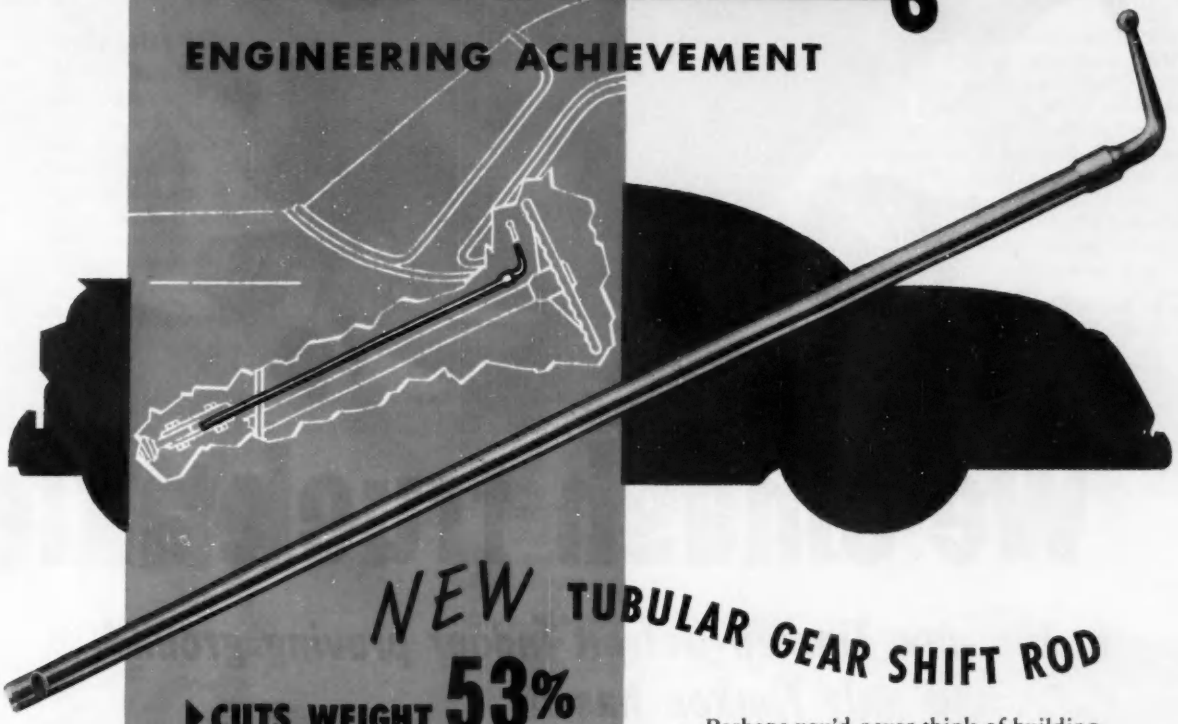
Ward Scott Bryson, Howard W. Buchanan, George E. Coyle, III, Charles W. Hipp, Jr., Wendell E. Marchant, James Thomas McCarter, George H. Michael, Mortlock Stratton Pettit, John W. Phillips, Jr., Paul S. Sawyers, M. Vane Wilks.

Foreign

Juan A. Brochiero, Argentina; Masao Ito, Japan; Werner Kahn, Brazil; Sydney Hyde Kemsley, Bermuda; Trevor Victor Krok, Australia; Hanji Umehara, Japan.

Another ROCHESTER PRODUCTS STEEL GM *tubing*

ENGINEERING ACHIEVEMENT



NEW TUBULAR GEAR SHIFT ROD

▶ **CUTS WEIGHT 53%**
...Yet Meets All Durability Requirements

▶ **LOWERS COSTS**

Perhaps you'd never think of building a gear shift rod from *tubing* . . . but Rochester Products did. The result is an ingeniously designed, soundly engineered GM Steel Tubing rod that will stand up under all conditions—yet weighs *less than half* as much as ordinary rods. Best of all, it COSTS LESS!

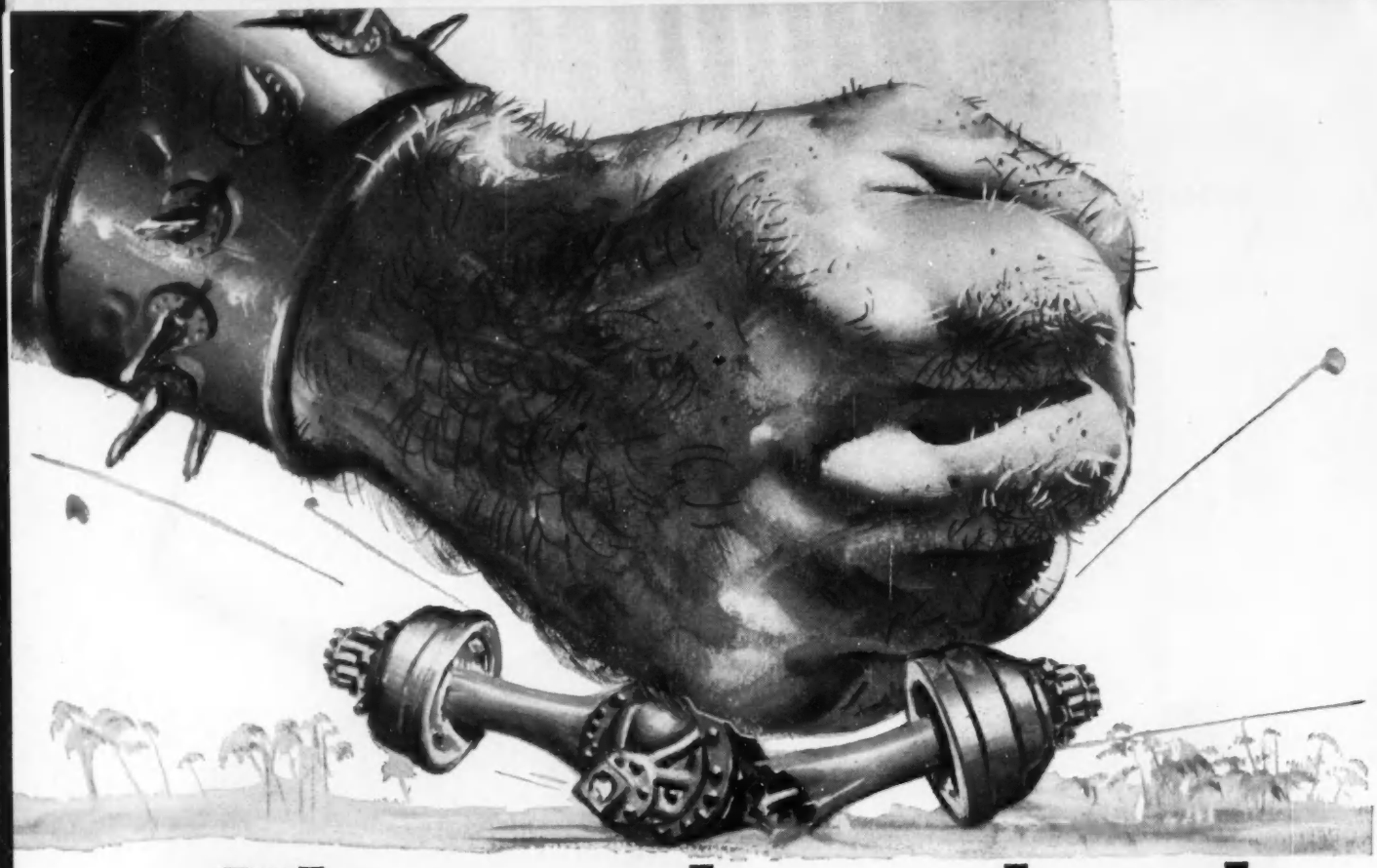
Here is one more example of how Rochester Products engineers are combining ideas, skill, experience and GM Steel Tubing to help hundreds of industries build *better products* for *less money.* We can help *you,* too!

SEND FOR *FREE* BROCHURE

Entitled *"Better Products for Greater Progress . . . ,"* this new, illustrated, fact-packed brochure tells how GM Steel Tubing can help solve design, production and cost problems. Send for your free copy today. Request Brochure No. 1120.

ROCHESTER PRODUCTS *DIVISION OF GENERAL MOTORS*
ROCHESTER, N. Y., U. S. A.
ALSO MANUFACTURERS OF ROCHESTER CARBURETORS AND ROCHESTER CIGAR LIGHTERS

RP
GM STEEL TUBING



We smash truck axles

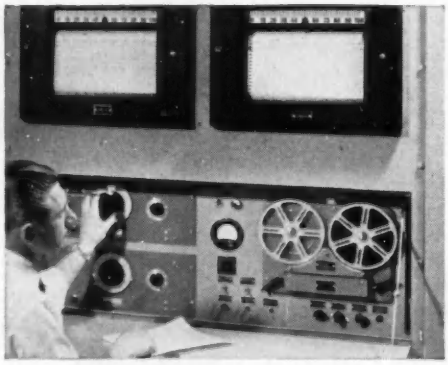
in the new Timken-Detroit indoor proving ground . . . and only Timken has it!

We twist, bend, jounce and jerk them. Duplicate every possible operating condition. Then toss in some "torture-tricks" of our own.

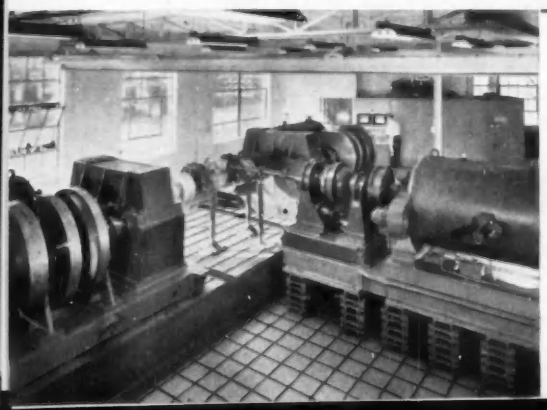
It's calculated destruction! But we know, and can tell you in advance, that a Timken-Detroit axle can take a murderous beating on the job.

Our "Torture Chamber" is a multi-thousand acre proving ground *capsuled into one room!* In it our engineers can put 50 years of experience to work . . . for you . . . experience gained in building axles for trucks, buses, trailers, farm machinery. Stock axles and gearing are subjected *indoors* to any *outdoor* operating condition—under scientific control and analysis.

The result? You enjoy longer axle life; less maintenance, repairs and downtime; lower operating costs, higher profits. Good reasons why Timken-Detroit axles are the choice of the leading manufacturers and owners.



This is our "Torture Tester." He gives axles and gearing the works in the "Torture Chamber." Above him are graphs showing speed and torque performance under any conceivable operating condition. Soft ground . . . twisting roads . . . long grades or fast highway speeds. With special dials, recorders, and electronic devices he actually *drives* the axle with scientific precision—*from his chair!*



How TDA proves axle quality in this "Torture Chamber"

We take an axle out of stock...then run a test like twisting the axle shaft 14°, backward and forward—36 times a minute, 24 hours a day, days on end. Or simulate a chuck hole shock every 4 seconds, 24 hours a day for months. Even "bend test" an axle housing for 1,000,000 cycles.

Now get more profitable truck performance than you ever dreamed possible! *Specify...*

TIMKEN-DETROIT 2-SPEED AXLES

because:

1. TDA two-speed double-reduction axles of Hypoid-Helical design provide both fast and slow ratios with two sets of "Man-Size" spur gears of liberal capacity. This simple design eliminates small, complicated arrangements of parts . . . improves performance . . . increases engine and gear life . . . cuts maintenance and repairs . . . fewer service parts required.

2. You get INSTANT, easy shifts . . . fast to slow—or slow to fast.

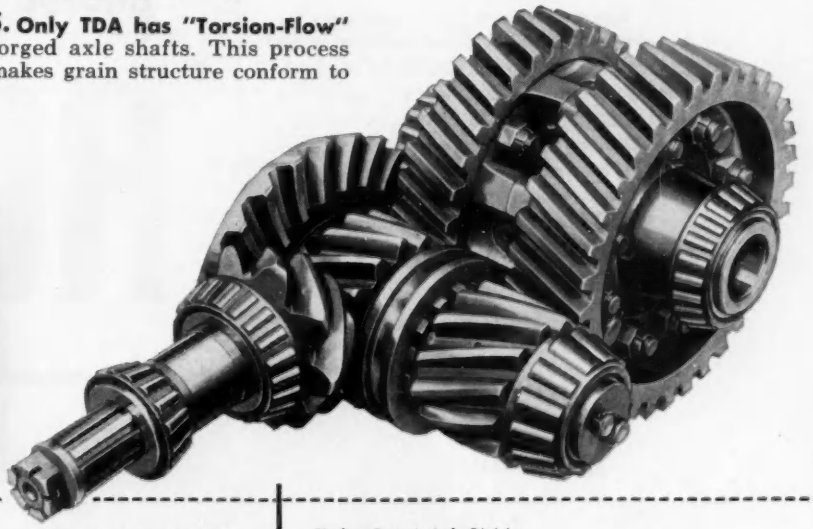
3. TDA's wider range of gear ratios . . . gives you combinations for any hauling requirement. For your present or new truck you can have a fast gear ratio for light loads everywhere—full loads on the level. Slow speed ratio for full loads on hills—for better pulling in "soft going." It all adds up to more profit per load and increased engine life.

4. Hypoid-Helical Gearing increases gear life . . . requires less maintenance. TDA two-speed axles give you a hypoid gear set in the first reduction . . . pinion is bigger . . . more teeth in contact, less load area per tooth. Larger pinion bearings and stronger ring gear. Torque transmitting capacity is increased. Only TDA offers a family of 7 basic axle capacities with interchangeable single speed, single reduction, single speed double reduction and two speed double reduction carriers.

5. Only TDA has "Torsion-Flow" forged axle shafts. This process makes grain structure conform to profile of shaft. Stresses are uniformly distributed throughout shaft—flange failures are practically nonexistent. Exclusive heat-treating formula gives tough, hard outer surface graduated toward center of shaft . . . the ideal combination of axle performance characteristics. TDA "Torsion-Flow" shafts have exclusive guarantee of 100,000 miles or three years, whichever occurs first.

6. Only TDA hot-forged steel axle housings prove in tests to be pound for pound the strongest, most rigid ever built. Actually deflect 20% less than conventional housings of same capacity. Rectangular TDA housing shape provides maximum strength, uniform stress distribution, with minimum weight. Ask about "Life of Vehicle" guarantee.

to bits



TIMKEN Detroit AXLES

TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

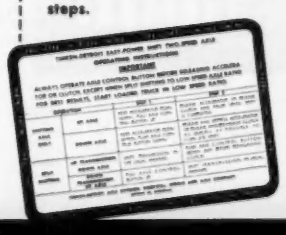
The Accepted TDA Standard
TRADE MARK REGISTERED

"TORTURE-TESTED"
to Save Money on the Job

WORLD'S LARGEST MANUFACTURERS OF AXLES FOR TRUCKS, BUSES AND TRAILERS

Plants at:
Detroit, Michigan
Oshkosh, Wisconsin • Utica, New York
Ashtabula, Kenton and Newark, Ohio
New Castle, Pennsylvania

FREE! Simple information card explains how Timken-Detroit Easy-Power Shift and Two-Speed axle operates when shifting axle only—or split shifting, in 2 easy steps.



Timken-Detroit Axle Division
Rockwell Spring and Axle Company
Detroit 32, Michigan

Please send me the free *information card* mentioned at left, explaining how the Timken-Detroit Easy-Power Shift Two-Speed Axle operates.

Name_____

Company_____

Address_____

City_____ State_____

Rohr builds more power packages for airplanes than any other company in the world — and this picture shows the Rohr-built power packages on the wing of the big, beautiful Lockheed Super Constellation. In addition to producing power packages for the world's leading commercial and military planes, Rohr Aircraftsmen are currently making more than 25,000 different parts for all types of aircraft.

power packages by

ROHR

WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES

ROHR
AIRCRAFT CORPORATION

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SAVE THIS CATALOG AND PRICE LIST — ATTACH CURRENT DISCOUNT SCHEDULE
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With Plain Steel SPACER TUBES

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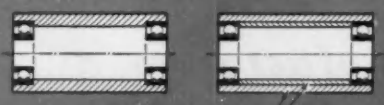
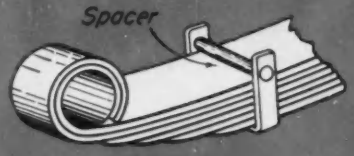
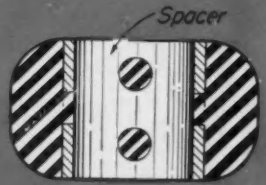


Two Spacers

Left—undercut machined wheel hub. This costly screw machine part was replaced . . . (right) . . . with two low-cost, nested, hand friction-fit spacers.



Leaf spring bolt spacer.



Steel insert sleeve, molded into nylon, provides anchorage for the nylon.

It is easy, quick and economical to order direct from this catalog. Spacers are money-saving, efficient replacements for costly machined parts, pipe or tubing (with concentricity held much closer). They come ready for assembly, eliminate machine time and scrap, and raw material handling in your plant. Order direct and save!

Write Today For Your Copy!

Your business letterhead request brings the new catalog and price list. See the savings you make with spacer tubes. Ask for your copy *today!*

FEDERAL-MOGUL SINCE FEDERAL Mogul 1899

FEDERAL-MOGUL CORPORATION
11035 SHOEMAKER • DETROIT 13, MICHIGAN

Schumacher Motor Express, Inc. of Eau Claire, Wisconsin, put their fleet of International "Midwesterners" on the haul between Chicago and the Twin Cities—single-stick shifting all the way through Fuller R-950-C ROADRANGER® Transmissions.

Leading Truck Manufacturers Standardize on Fuller Transmissions

. . . for Fuller Transmissions have *proven* themselves in all types of on-and-off highway service, where load-and-road conditions are the toughest. Outstanding performance and *customer satisfaction* has created such a demand that leading truck manufacturers have *standardized* on Fuller Transmissions.

Famous "extras" that mean longer wear life, quiet operation, easy shifting are: . . . crowned gear teeth that reduce load concentration . . . offset mating gears to limit load concentration.

More than 110 different models are available, for trucks from 100 to 400 hp, engines from 330 to 1440 cubic inches . . . there is a Fuller Transmission *designed* with your job in mind . . . ready to help you move more, *for less.* Check with your local truck dealer for the *right Fuller* Transmission for your job.

where horsepower *really* goes to work

Fuller TRANSMISSIONS®

FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO, MICHIGAN

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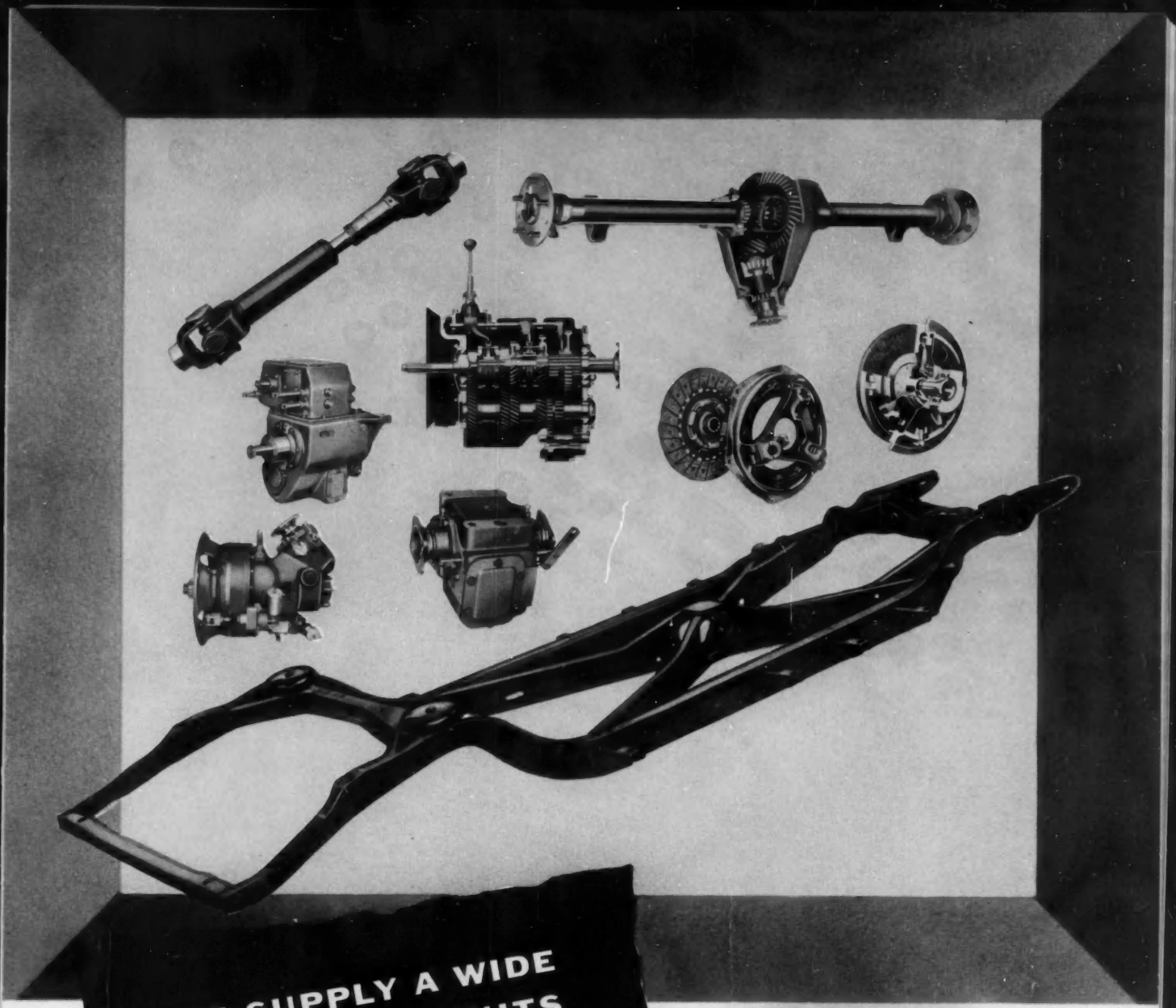

WE SUPPLY A WIDE VARIETY OF UNITS TO THE AUTOMOTIVE INDUSTRY

The Dana enterprises are widely diversified in their application to the modern automobile, truck, bus, tractor, and other types of vehicles.

This is the result of 50 years of steady growth and service to the industry. Since 1904, the world has seen many changes in automotive engineering. Dana has kept pace with these advancements, designing and developing many different functional units that are considered

"The Standard of the Industry"

ENGINEERING

DANA

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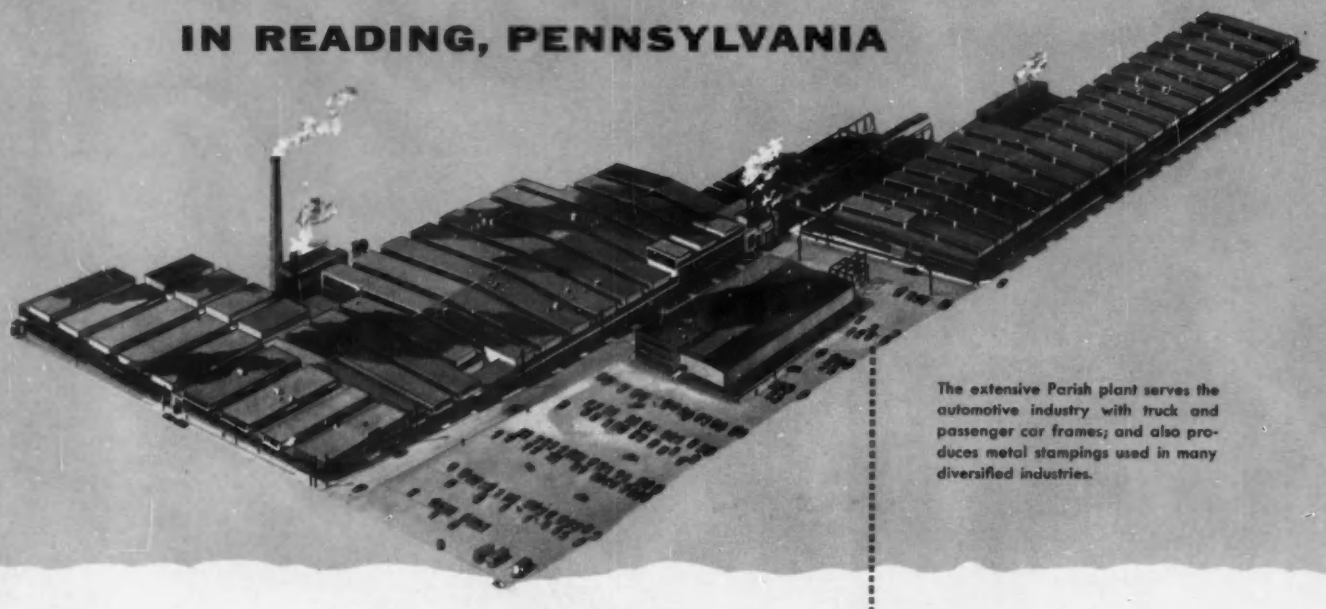
THIS IS THE PARISH PRESSED STEEL COMPANY IN READING, PENNSYLVANIA



The extensive Parish plant serves the automotive industry with truck and passenger car frames; and also produces metal stampings used in many diversified industries.

PRODUCER OF QUALITY CHASSIS FRAMES

for Many Leading Manufacturers of Automotive Vehicles

Modern production equipment combined with manufacturing "know how" are prerequisites for supplying chassis frames to manufacturers of passenger cars and other automotive vehicles. Facilities at Parish Pressed Steel meet these requirements; and are also ideally suited to the production of a wide variety of pressed metal parts and assemblies.

Parish is a substantial supplier of frames for the Automobile, Truck, Bus and Trailer Industries, as well as a large number of other parts for the Automotive, Appliance, Railroad and general manufacturing industries.

PPS

PARISH

Pressed Steel Company, Reading, Pa.

(A Wholly-Owned Subsidiary of Dana Corporation)

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Continuous Operation High Production Accurate Flat Surfaces

No time lost in loading and unloading parts on new Model 844 Microflat Machine.

New type multiple-station, self-actuated fixture and more selective controls give this machine a production capacity of a finished part every 3 seconds.

For complete description of this new Microflat Machine write for CROSS-HATCH, Vol. 6, No. 1.

1929 • 1954 — 25TH YEAR OF DEVELOPMENT — PRECISION PRODUCTION THROUGH MICROHONING — MICRO MATIC

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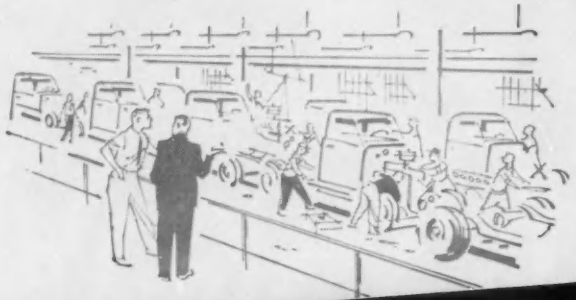
Hydraulic Controls • Diesel fuel injection equipment

if the SERVICE MANAGER built the truck he services



ZENITH CARBURETORS

would still be *his* choice

Ask any service manager why he prefers Zenith* Carburetors and you will get a ready reply.

For shrewd parts and service managers know that with the Zenith Standardized Carburetor Service Program they can actually service more makes and models with a smaller inventory investment. Yes, operating costs go down, profits up, and customers are happier with Zenith Carburetor service.

There just isn't a question about it—if parts and service managers were in the business of selecting carburetors for standard equipment Zenith would be their choice.

This sounds like a pretty good reason why—if you build, buy, sell or operate trucks, Zenith should be your choice for the best in carburetion. *REG. U. S. PAT. OFF.

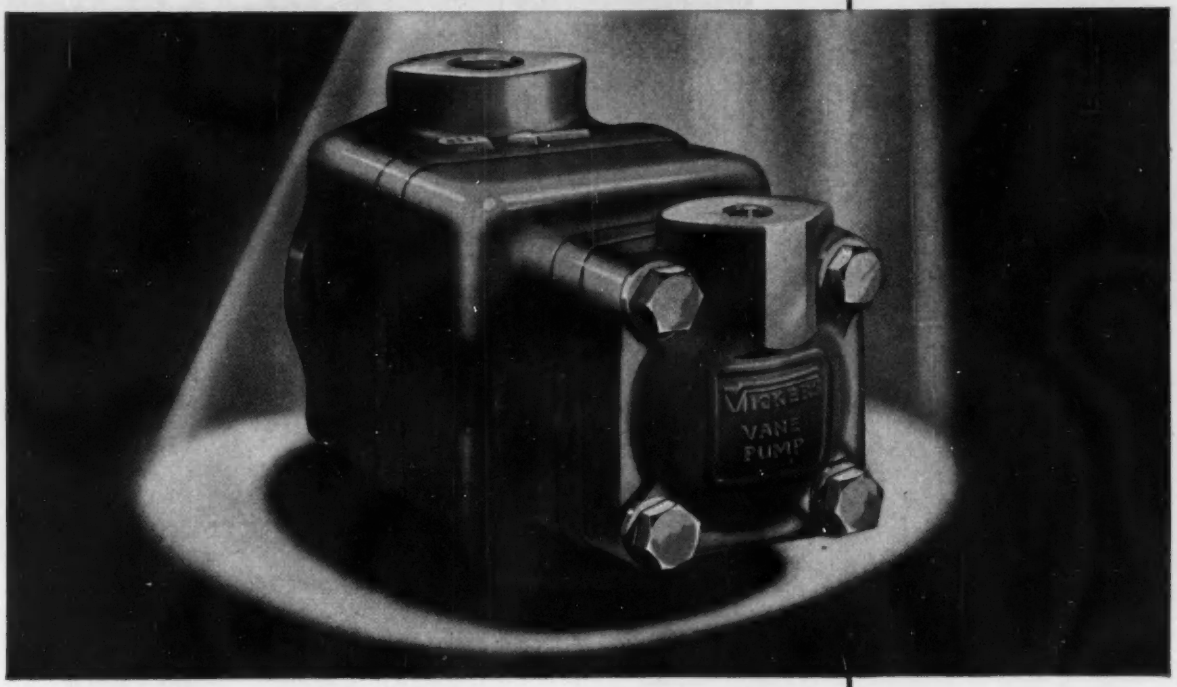
ZENITH CARBURETOR DIVISION OF Bendix AVIATION CORPORATION

696 Hart Avenue • Detroit 14, Michigan • Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

ONE OF A SERIES

You Get Many Benefits by Specifying VICKERS® Hydraulics

Long-Established QUALITY



Certain names and designations have become synonymous with long-established quality in consumer products. Some that you will recognize are Sterling, Sheffield, Wedgwood, etc. Similarly, certain names signify long-established quality in industrial products . . . you can think of many with little difficulty.

Among the latter is VICKERS . . . for long-established quality in Hydraulics. For more than a quarter century, the mark VICKERS has signified superior products and services . . . with continuous pioneering in hydraulics research and development. As a result, the list of leading manufacturers who use Vickers Hydraulics continues to grow. You also can get the benefits of this dependable, long-established quality by specifying Vickers Oil Hydraulic Equipment.

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Incorporated
DIVISION OF THE SPERRY CORPORATION
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CHRYSLER'S

235-HORSEPOWER

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CHRYSLER

Most powerful engine in any American passenger car,
Chrysler's "Fire Power" maintains the reputation
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By combining their broad knowledge with
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Chrysler engineers continue to give Chrysler owners
outstanding automobile performance at lowest cost.

VALVE DIVISION

Thompson Products, Inc.

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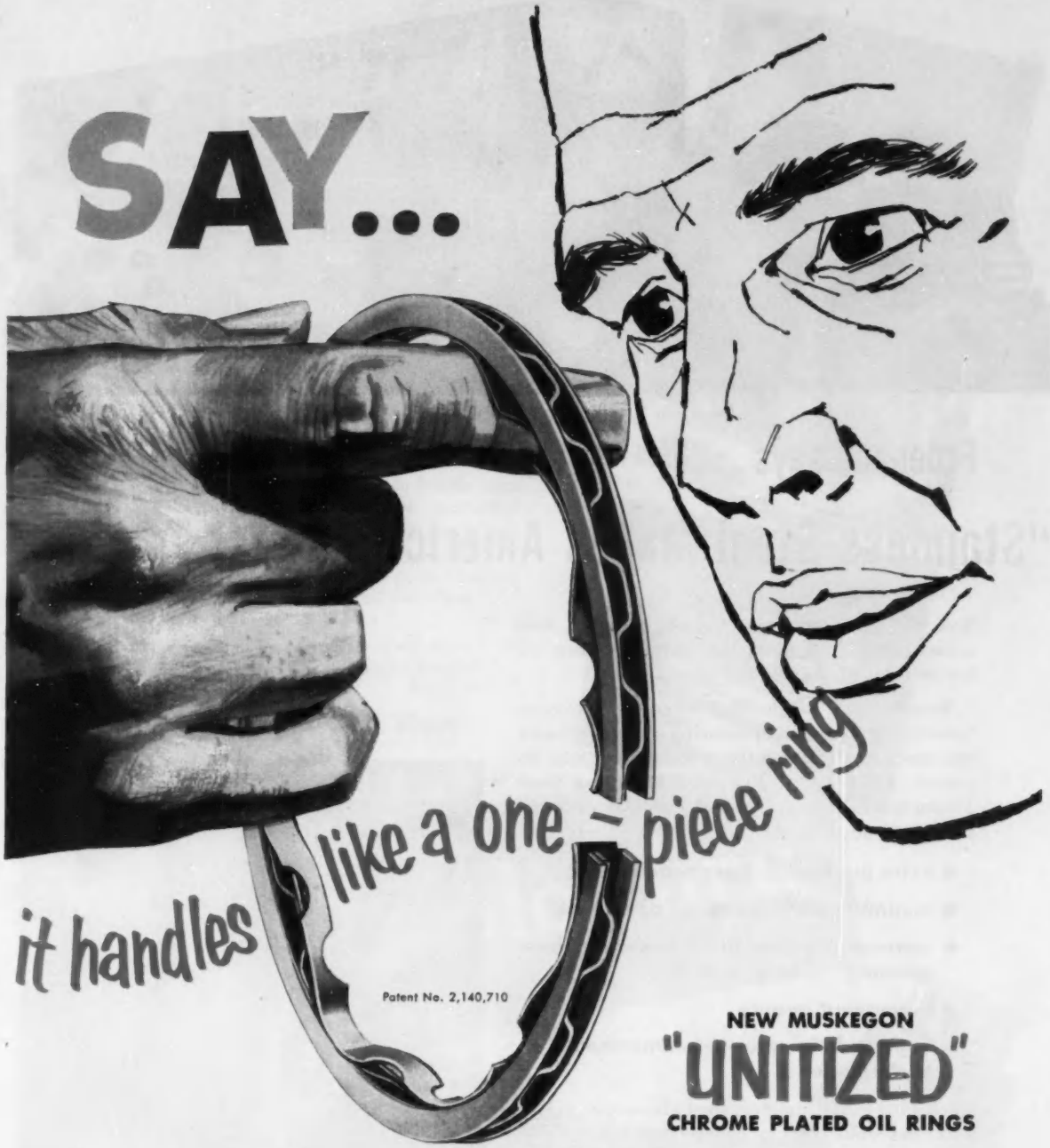

NEW MUSKEGON
"UNITIZED"
CHROME PLATED OIL RINGS

"A great idea!" "Why wasn't it done before?"

That's what you'll hear when the assembly-line talk gets around to Muskegon's amazingly different "Unitized" ring . . . the multiple-piece ring that *handles* like a one-piece ring. And no wonder, for look at all the advantages you get. Installation is fast, easy and accurate. There's no fumbling, no chance for error. And when the engine is run, hot oil dissolves the special adhesive—ring components separate and run free.

But there's more to the "Unitized" story. Rails are *chrome plated* to reduce ring and bore wear, scuffing and friction—keep engine performance like-new, oil economy high . . . yet the cost of Muskegon's "Unitized" ring is just *half* that of chrome-plated cast iron oil rings.

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Piston Rings
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PLANTS AT MUSKEGON AND SPARTA

Since 1921... The engine builders' source!

Fruehauf says . . .

"Stainless Steel Makes America's Finest Trailers"

Yes, austenitic chromium-nickel stainless steel makes possible the finest and, in the long run, the lowest cost trailers you can buy...

Because this tough, high strength, corrosion-resisting metal permits producing a lifetime trailer that gives maximum on-the-road use per dollar invested. Actually, no Fruehauf Stainless Steel Trailer has ever been reported worn out. And consider these advantages:

- **extra payload . . . less deadweight**
- **minimum profit-wasting "down time"**
- **corrosion-resisting metal never requires painting . . . easy to clean**
- **permanent beauty**
- **high trade-in value . . . unmatched performance**

Chromium-nickel stainless steel allows you to trim bulk, and make parts much lighter in weight while still providing ample structural strength. Use it where you need high resistance to impact, wear, abrasion and corrosion. Chromium-nickel stainless steels can be drawn, spun, forged, welded, soldered, punched, sheared or bent.

Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. A list of sources of supply will be furnished on request.

The corrugated panels on Fruehauf Stainless Steel Trailers are Type 301 (18-8) Stainless, 15/1000 of an inch in thickness. Though it is very thin, this metal is extremely strong in its corrugated form. Chromium-nickel stainless of different types and thicknesses are used in other parts of the trailer and frame. Product of FRUEHAUF TRAILER CO., Detroit 32, Michigan.

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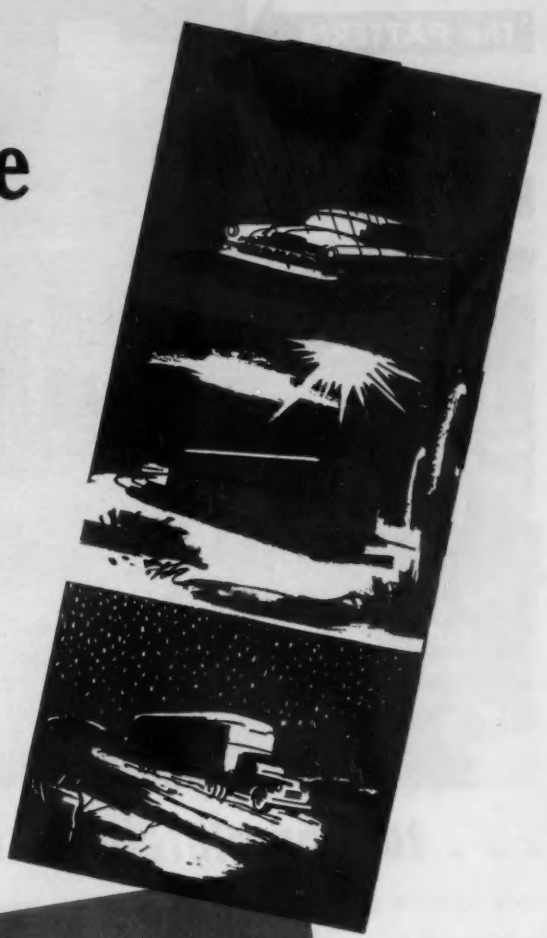
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

more dependable starting *under all operating conditions*



"No Kick-Out" feature sets new standards in starting performance.

● Since the earliest days of the automotive industry Bendix* Starter Drives have been noted for reliable starting.

Now with the new and latest Bendix Folo-Thru Starter Drive, starting, even under the most adverse weather conditions, has been improved immeasurably.

Although this new Bendix Starter Drive is fundamentally similar to its illustrious predecessors, it is specially designed to follow through the weak explosions until the engine actually runs on its own power.

That's why cars, trucks and buses equipped with the Bendix Folo-Thru Drive are easier and quicker to start under all operating conditions.

*REG. U.S. PAT. OFF.

ECLIPSE MACHINE DIVISION OF Bendix AVIATION CORPORATION

ELMIRA, NEW YORK

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

Bendix folo-thru starter drive

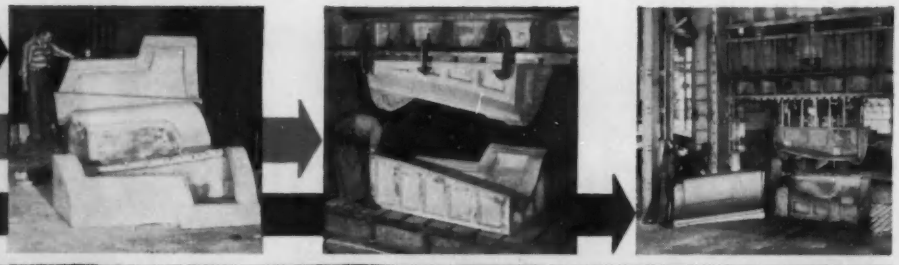
costs less—*The new Folo-Thru Drive requires no actuating linkage and the less expensive solenoid may be placed in any convenient position. Results are lower installation costs and no adjustments. Complete detailed information is available on request.*

Bendix* Folo-Thru Starter Drive **Bendix* Automotive Electric Fuel Pump** **Stromberg* Aeroquad Carburetor**

The PATTERN

The DIE

The STAMPING



. . . to Completely Finished PROTOTYPE PARTS

READY FOR ASSEMBLY

It's Allied that offers the *complete* service to provide you with die-made prototype parts.

Plaster patterns . . . low-cost, quickly-produced dies made of plastic or zinc alloy . . . stampings accurately drawn and formed on Allied presses . . . completed parts which have been hand trimmed, flanged, pierced and spot finished . . . are all produced by Allied.

Not only is full responsibility for such a prototype program centered at one source but many economies can be effected from which you as a customer can benefit. In the building of the dies, for example, combinations of plastic, zinc alloy or steel (all of which Allied supplies) give you the best and most economical tooling for your volume requirements. In the finishing processes, as one more example, the tools themselves are often used for flanging and other purposes—additional cost-saving and accuracy-assuring operations.

If you need sheet metal stampings for prototype assemblies, you should investigate Allied's all-inclusive service. A visit to our Plant 4 in Hillsdale, Michigan will convince you that here is a positive method of insuring an economical and rapid transition from prototype to high volume production. If a visit is not convenient, let us supply you with complete information.

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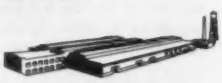
Detroit, Mich.

PLANT 2
Detroit, Mich.

PLANT 3
Hillsdale, Mich.



PLANT 4
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STAINLESS
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High quality stainless sheet and strip steel . . . for the product you make today and the product you plan for tomorrow.

McLouth Steel Corporation
DETROIT, MICHIGAN
Manufacturers of Stainless and Carbon Steels

- for engine capacities from 135 to 600 lbs.-ft. torque
- single or double plate
- plate sizes from 9 to 17 inches

LONG

...for heavy-duty clutch requirements

B-W

Insistence upon the finest quality has been an inflexible practice at the Long Manufacturing Division for over 50 years. Long quality is proven with the millions of Long Clutches being road tested every day on cars, trucks, buses and tractors.

LONG MANUFACTURING DIVISION • BORG-WARNER CORPORATION

Detroit 12, Michigan, and Windsor, Ontario

CLUTCHES • RADIATORS • TORQUE CONVERTERS • OIL COOLERS

Eatonite-Faced Valves Last Longer

- **Eatonite is heat resistant, wear resistant, corrosion resistant**
- **Eatonite adds materially to valve life in commercial vehicles and heavy-duty industrial engines**
- **A special process developed by Eaton produces a homogenous bond between the valve seat and the hard facing metal**
- **Eatonite-faced valves pay for themselves many times over in freedom from valve trouble and lengthened life-span**

Applied by Special Eaton-developed Techniques.

Available as solid valves, hollow sodium-cooled valves, or free-valves.

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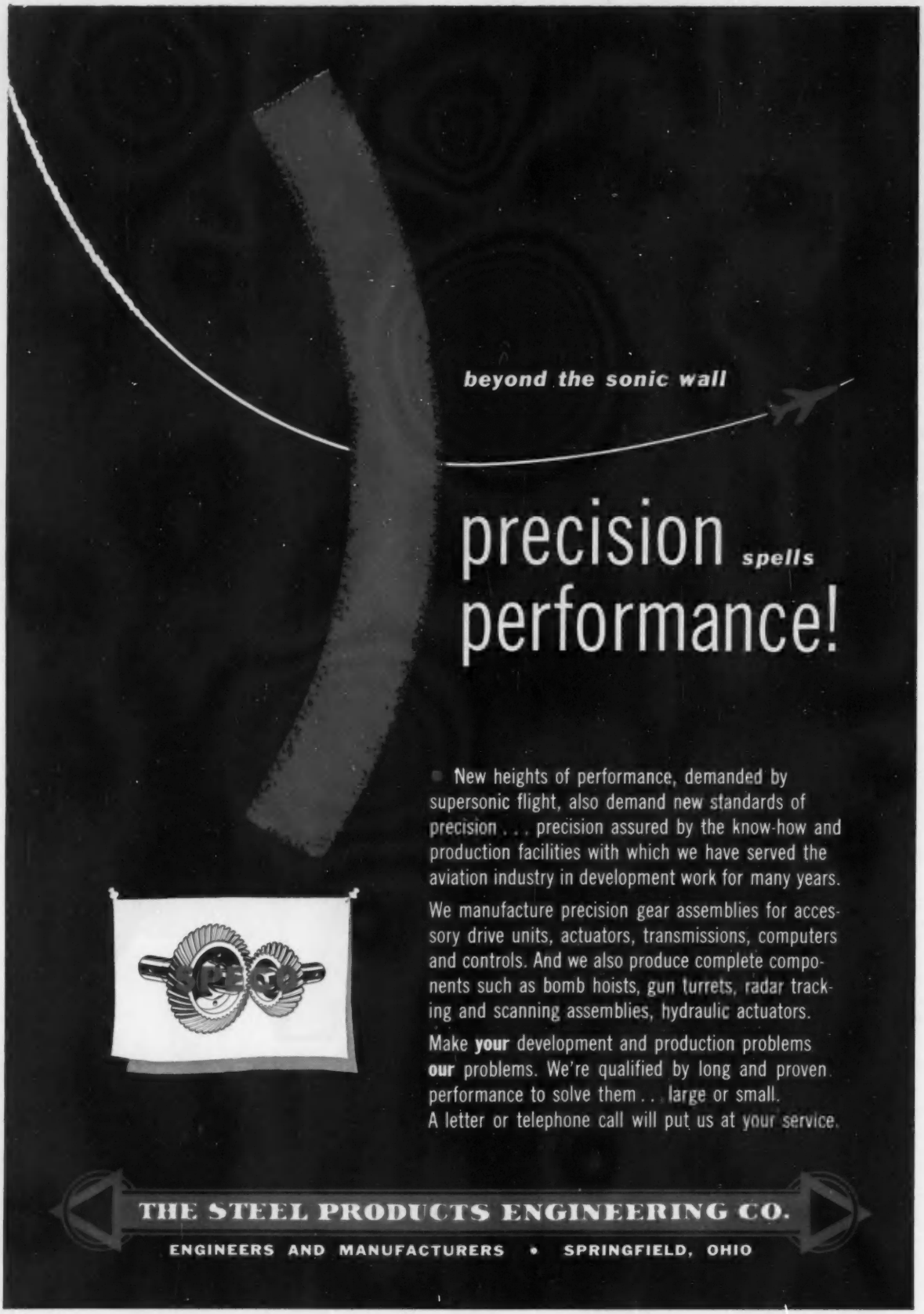
VALVE DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers


beyond the sonic wall
precision spells performance!
New heights of performance, demanded by supersonic flight, also demand new standards of precision . . . precision assured by the know-how and production facilities with which we have served the aviation industry in development work for many years.
We manufacture precision gear assemblies for accessory drive units, actuators, transmissions, computers and controls. And we also produce complete components such as bomb hoists, gun turrets, radar tracking and scanning assemblies, hydraulic actuators.
Make your development and production problems our problems. We're qualified by long and proven performance to solve them . . . large or small.
A letter or telephone call will put us at your service.
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ENGINEERS AND MANUFACTURERS • SPRINGFIELD, OHIO

First and Foremost

AC pioneered the self-adjusting "Knee-Action" pressure cap...

AC leads in production of radiator pressure caps

This is the story of a radiator cap that helped to restyle an automobile. Sounds like a tall order, doesn't it?

The first radiator pressure cap was introduced in 1936 to increase cooling efficiency, prevent evaporation and surge losses. It did these things well so long as the seat was level and the loose gasket didn't get lost during servicing.

Then, in 1940, AC pioneered the self-adjusting "Knee-Action" pressure cap with integral gasket. Both problems were solved; solutions quickly adopted by the industry.

With pressure cooling an entirely new kind of automotive styling became practical, making it possible to lower the radiator and give the car low, sleek, modern lines.

AC pressure caps are on more than 70% of today's cars. This is another example of the creative engineering and volume production which have made AC foremost in its field.

If you need help in solving a tough problem, why not call or write one of the AC offices below:

For More than Twenty Years Every Make of Car Has Used One or More AC Products

• ADAPTERS (Drive) • AIR CLEANERS • AIR CLEANERS AND SILENCERS (Combination) • AMMETERS • BREATHERS (Crankcase) • CAPS (Radiator Pressure) • FLEXIBLE SHAFT ASSEMBLIES • FUEL PUMPS • FUEL AND VACUUM PUMPS (Combination) • FUEL FILTERS & STRAINERS • GASOLINE STRAINERS • GAUGES—AIR (Pressure) • GAUGES—GASOLINE • GAUGES—OIL (Pressure) • GAUGES—TEMPERATURE (Water, Oil) • OIL FILTERS (Lube) • PANELS (Instrument) • SPARK PLUGS • SPEEDOMETERS • TACHOMETERS • TERMINALS (Ignition Wire) • VALVES (Crankcase Ventilation)

AC QUALITY PRODUCTS

FLINT—1300 North Dort Hy.
CHICAGO—Insurance Center Bldg.
DETROIT—General Motors Bldg.

AC SPARK PLUG DIVISION GM GENERAL MOTORS CORPORATION

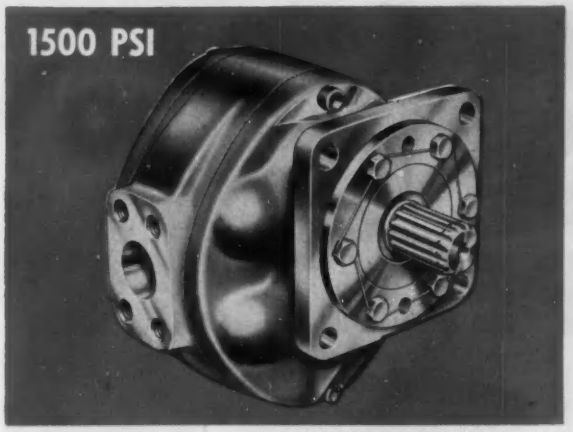
FOUR...

COMPLETELY NEW LINES OF HYDRAULIC PUMPS WHICH GIVE YOU FAR MORE IN PERFORMANCE AT FAR LESS IN COST!

- Pumps to give new life to existing equipment . . . to improve performance, increase capacity!
- Pumps that afford the design engineer the basic equipment for entirely new concepts in hydraulically operated machines!
- Pumps for machines to do work better, quicker, cheaper!

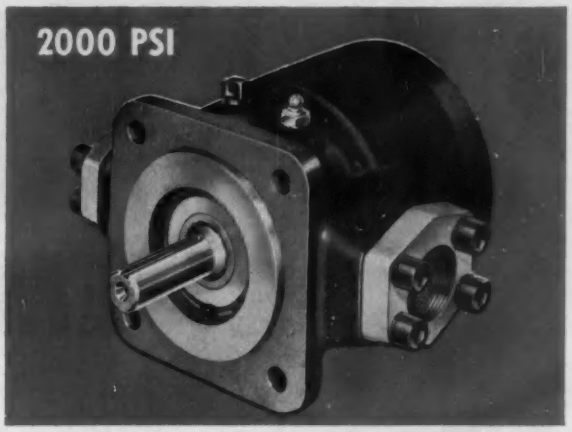
THE NEW YORK AIR BRAKE COMPANY

1101 EAST 222nd STREET • CLEVELAND 17 • OHIO



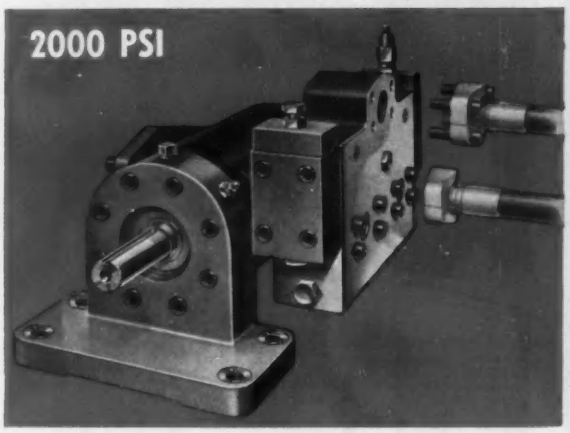
SERIES H GEAR-TYPE PUMPS

The HYDRECO Series H Pumps are intended for use in the hydraulic systems of heavy-duty mobile and industrial equipment, especially where shock loads, impact and rugged service are "normal working conditions". Four sizes (40, 50, 60, 70 gpm) deliver fluid power at 1500 psi . . . increased horsepower gives greater work output. *Pressure-Balanced* wear plates reduce oil slippage and eliminate power-robbing frictional contacts. SAE Flange Mounting and split-flange hose connections make servicing simple and reduce down-time. Equipment is on-the-job longer.



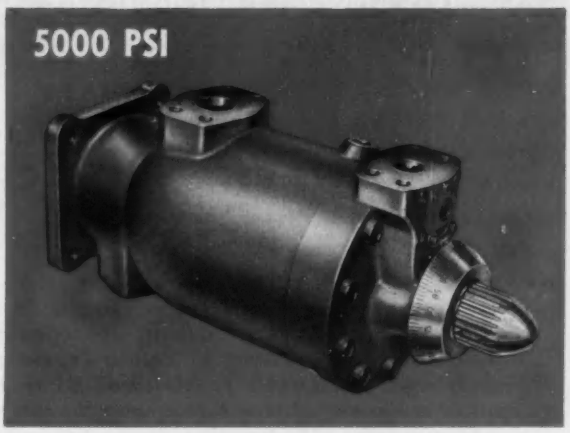
SERIES PF-100 VANE-TYPE PUMPS

DUDCO PF-100 Series Pumps can double the value of your *hydraulic dollar*. You get 2000 psi continuous duty, single-stage construction for the cost of equal capacity low pressure pumps . . . improved equipment design and increased machine efficiency without the payment of premium prices. These Pumps feature a simplified, 3-unit construction . . . the pumping cartridge incorporates the famous DUAL-VANE design which provides and assures complete balance of all hydraulic pressure loads. These Pumps have capacities of 3, 5, 8 and 11 gpm at 1200 rpm.



SERIES PF-100 DOUBLE PUMPS WITH VALVE PANELS

DUDCO PF-100 Series Double Pumps with Valve Panels are versatile units unmatched as a source of *Controlled Fluid Power* for a wide variety of modern industrial equipment . . . for 2000 psi operation of circuits calling for a substantial variation in pump volume as during "close and hold" or "traverse and feed" cycles. The Valve Panel contains the valving necessary for pressure regulation and flow control . . . the external part of a system will have less valves and controls, reduced piping and fewer parts to maintain. Ten capacity combinations with either automatic or remotely controlled operation.



SERIES PV-600 PISTON-TYPE PUMPS

DUDCO PV-600 Series Variable Delivery Pumps generate continuous duty pressures up to 5000 psi. Two types of controls match pump output to system demands. A pressure-compensated regulator automatically varies the volume in response to system pressure. A hand wheel control enables an operator to vary the volume during the machine cycle. High pressure variable delivery means power is transmitted without the necessity for an accumulator and without any wastage of power thru a relief valve.

WRITE TODAY . . .

Get full particulars on these important new developments in hydraulic pumps!

The New York Air Brake Company
1101 East 222nd Street
Cleveland 17, Ohio

Please send details on

- ☐ SERIES PF-100 VANE-TYPE PUMPS
- ☐ SERIES H GEAR-TYPE PUMPS
- ☐ SERIES PF-100 DOUBLE PUMPS WITH VALVE PANELS
- ☐ SERIES PV-600 PISTON-TYPE PUMPS

Name_____

Address_____

City_____ Zone_____ State_____

Sensational Piston Performance

UNIFORM CLEARANCE AT ALL TEMPERATURES

STEEL TENSION MEMBER

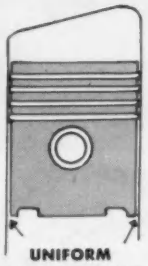
Anchored only at pin bosses and cast in positive contact with I. D. of piston skirt

Controls Clearance Automatically

Design adaptable to full skirted or slipper-type pistons for gasoline engines for every purpose.

ZOLLNER CLEAR-O-MATIC PISTONS

Now, pistons may be fitted to closer clearances than ever before possible. The sensational development of CLEAR-O-MATIC Pistons by Zollner engineers *reduces required clearance to less than .001 with constant uniformity of skirt bearing over the entire temperature range.* Performance results are spectacular. Engines run quietly with no cold slap. Friction is reduced without loss of durability or heat conductivity. There is no danger of scuffing or seizing. The Zollner designed steel tension member incorporates in the aluminum piston the same effective expansion as the ferrous cylinder itself. We urge your immediate test of these sensational advantages for your engine.



UNIFORM EFFECTIVE SKIRT CLEARANCE AT ALL TEMPERATURES

1. Clearance maintained uniformly at all coolant temperatures from 20° below zero to 200° F.
2. Effective expansion identical with ferrous cylinder.
3. Steel tension member, with same effective expansion as cylinder, maintains uniform skirt clearance through entire temperature range.
4. Normal diametric clearance usually less than .001 with uniform skirt bearing.
5. Durability and conductivity comparable to heavy duty design.

THE ORIGINAL EQUIPMENT PISTONS

ZOLLNER PISTONS

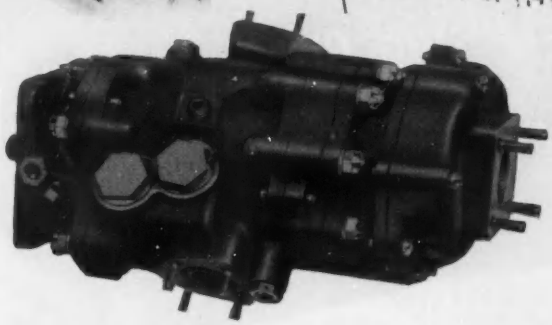
ZOLLNER

- ADVANCED ENGINEERING
- PRECISION PRODUCTION

in cooperation with engine builders

ZOLLNER MACHINE WORKS • Fort Wayne, Indiana

FOR CONTINUOUS NEW PUMP PERFORMANCE *and* DEPENDABILITY...



Pesco Model No. 022664 Engine-driven Dual Fuel Pump with inlet booster, for turbo-jet engine applications. 40 gpm @ 600 psig and 3690 rpm. Weight approximately 23.5 lbs.

YOU CAN RELY ON PESCO *Pressure Loaded* PUMPS FOR THESE ADVANTAGES

- DEPENDABLE PERFORMANCE
- LESS INSTALLATION SPACE REQUIRED
- LESS MAINTENANCE

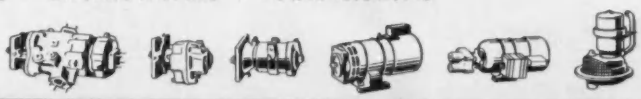
Aircraft engineers and operators know from experience that they can rely on PESCO "Pressure-Loaded" PUMPS for continuous "new pump" performance and operating dependability over a wide range of temperatures. These PESCO pump characteristics are the result of many years experience devoted exclusively to the development of fuel, air, and hydraulic pumps, hydraulic and electric motors, and accessory units.

The Pesco policy of continuous research and development, plus Pesco's complete facilities for advanced engineering, high-precision production and thorough testing all contribute to provide the one best product for your specific application.

These facilities are available for your immediate use. Simply call or write the Home Office, Bedford, Ohio.

Call or write the Home Office, Bedford, Ohio for full information on these Pesco products as applied to your specific installation.

HYDRAULIC PUMPS • BOOSTER PUMPS • FUEL PUMPS
AIR PUMPS • ELECTRIC MOTORS • POWER PACKAGES



engineering Pesco production
PRODUCTS DIVISION

BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

Among leading automotive manufacturers
the swing's to timing chain...

and LINK-BELT Timing Chain gives you these 3 BIG advantages

Segmental bushings provide automatic joint snugness

Segmental bushings are made with slight bow.

After initial assembly in chain, bushings are straight.

Bow in bushing acts to keep a snug joint.

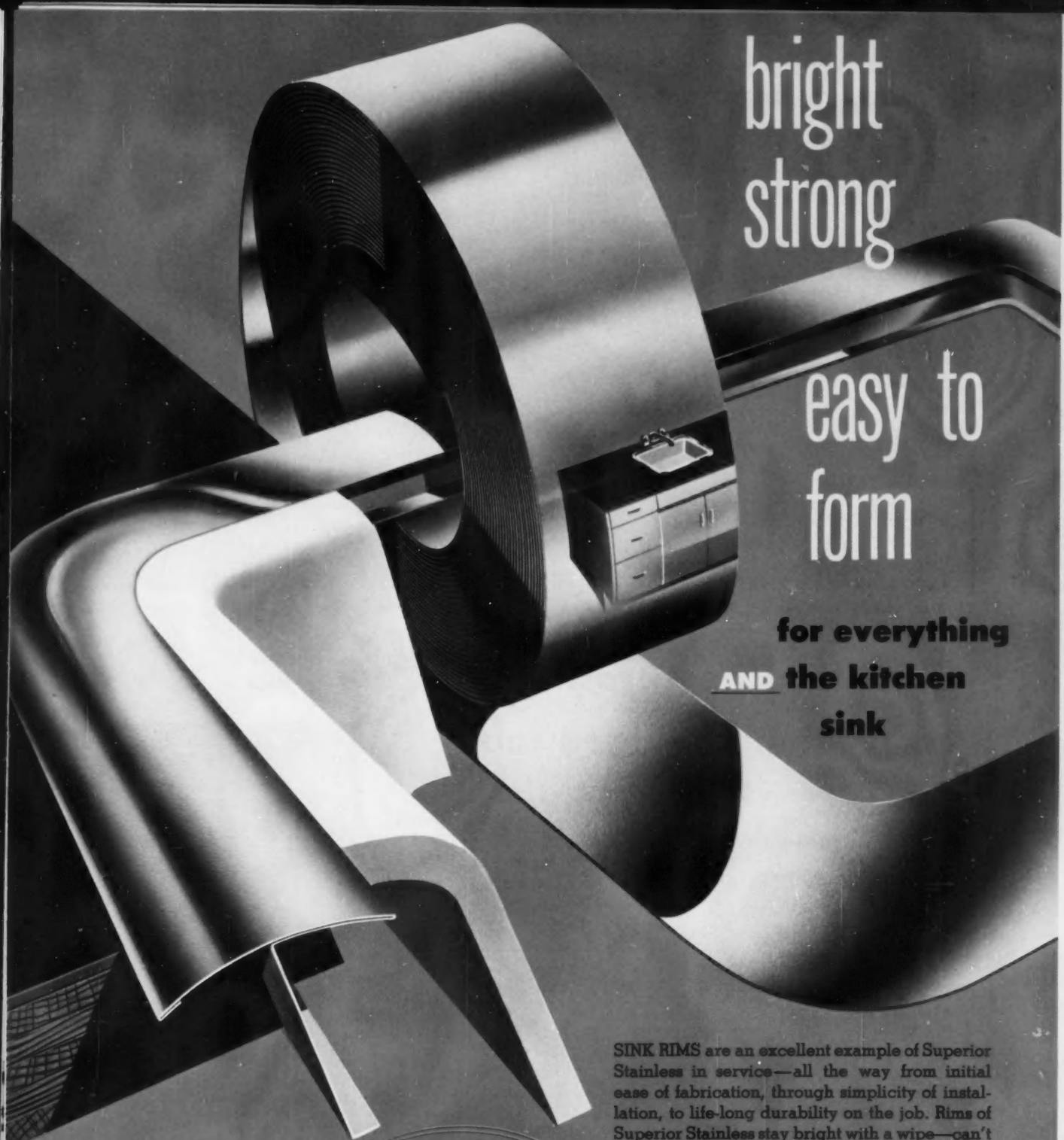
1. **Automatic joint snugness**
2. **Smoother operation**
3. **Longer life**

YES, more and more new automobile engines are being designed for timing chain. And when it comes to timing chain—no other make can match Link-Belt's outstanding advantages. What's more, the tremendous facilities of the Link-Belt plant—the world's largest chain plant—assure you a dependable source. Our engineers will supply a test drive to your specifications. For full information, ask for Book 2065. 13.344

LINK-BELT

TIMING CHAINS and SPROCKETS

LINK-BELT COMPANY: 220 South Belmont Ave., Indianapolis 6, Ind. Offices in principal cities.



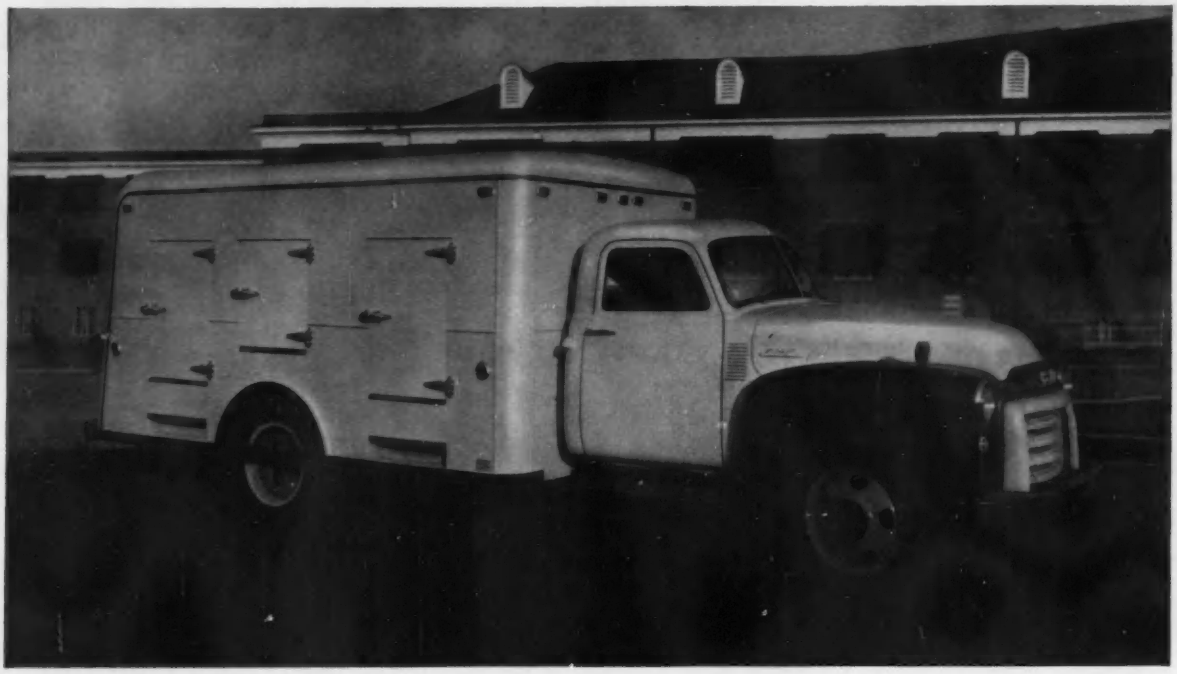
bright strong easy to form

for everything AND the kitchen sink

Superior *Type* 430 **Stainless** STRIP STEEL

SINK RIMS are an excellent example of Superior Stainless in service—all the way from initial ease of fabrication, through simplicity of installation, to life-long durability on the job. Rims of Superior Stainless stay bright with a wipe—can't rust, peel or chip—add value to the entire kitchen unit! • Let's help you find *your* profit-application for Superior Stainless Strip Steel. Write us about your product, today.

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA



Hackney-built refrigerator body, with Mayari R corner posts. The need for replacement corners dropped noticeably when Mayari R was put in.

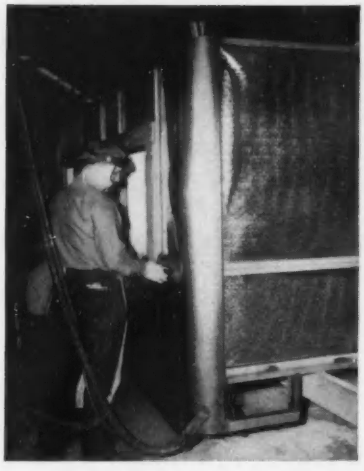
How Hackney Bros. uses *Mayari R* as a "double-edged tool"

Just 100 years ago, W. N. Hackney opened up shop in Wilson, N. C., to make wheels and other parts for wagons and buggies. Today, three generations later, Hackney Bros. Body Co. is the thriving builder of bodies for commercial vehicles like the ice cream truck shown above.

Important in the manufacture of many Hackney bodies is Mayari R low-alloy, high-tensile steel. The Hackney people take good advantage of Mayari R's high yield point of 50,000 psi – one and one-half times that of plain carbon steel. "For our use, Mayari R is a double-edged tool," they say. "With it, we can maintain equivalent frame strength with a reduction in weight, or . . . obtain greatly increased strength without increase in weight."

They also find that Mayari R brings added sales appeal to their products, because of widespread customer acceptance of high-strength steel. Throughout the automotive industry, more and more vehicle manufacturers are using Mayari R . . . for framing members, gussets, roof bows, side sheets and other parts in which strength and weight are critical factors.

Our new Catalog 353 illustrates the wide range of applications that is evidence of the growing demand for Mayari R. We'll be glad to send you a copy; just call our nearest office.



Construction view showing corner post made of Mayari R that has been welded in place. This refrigerator body is lined with Bethcon continuously galvanized sheets.

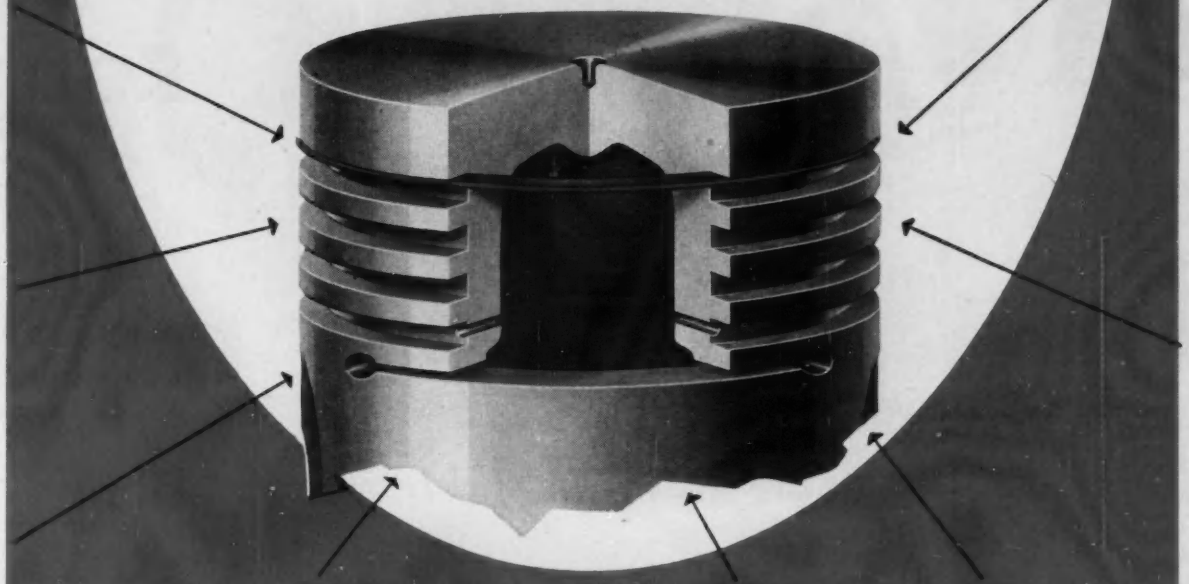
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: *Bethlehem Steel Export Corporation*

BETHLEHEM STEEL

Mayari R *makes it lighter... stronger... longer lasting*

Adopted by leading engine builders

... for original equipment ... for service departments



Sealed Power GI-60 Groove Insert

INCREASES PISTON LIFE TO AS MUCH AS 200,000 MILES!

Pioneered by Sealed Power engineers and proved by experience to be the only dependable, economical answer to top-ring-groove wear, Sealed Power GI-60 Contracting Groove Insert is steadily gaining in popularity with engine manufacturers.

They can't ignore the testimony of fleet owners who have reported that GI-60 has increased *average piston life* to over 200,000 in the toughest kind of service. Several engine builders now make GI-60 standard equipment in new engines. Others are using it in replacement pistons.

Sealed Power GI-60 is a heat-treated spring-steel insert, securely anchored to the top of the ring groove after regrooving to a true surface 1/32" wider than before. A 1/32" recess is then cut at the top and the insert locks itself permanently into place, held by its own inward tension and dished to hug the top of the groove.

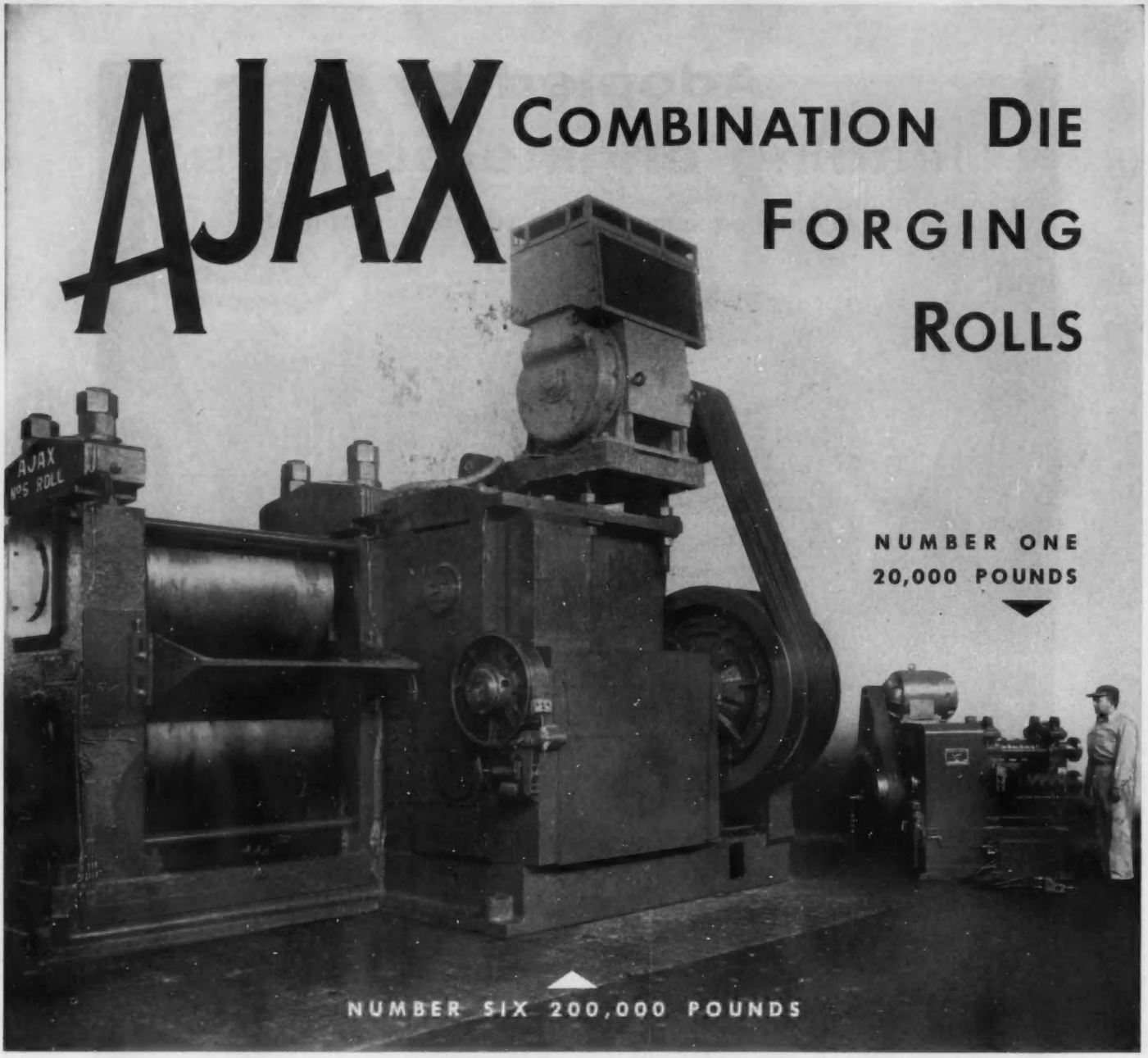
This armor-plate protection gives the top ring groove protection it can't get in any other way. This groove is in the hottest, least-lubricated spot in the piston. GI-60 resists the pounding, the heat, and the friction far better than aluminum or cast iron possibly can. That's why it adds thousands of miles of life to both new and replacement pistons ... *"makes old pistons new, keeps new pistons young."*

Sealed Power Corporation

MUSKEGON, MICHIGAN

Sole manufacturers of KromeX Ring Sets, MD-50 Steel Oil Ring, Full-Flow Spring, Flex-S Flexible Oil Ring, and GI-60 Groove Insert. Leading producer of Automatic Transmission Rings, Power Steering Rings, and Non-Spin Oil Rings

AJAX COMBINATION DIE FORGING ROLLS



NUMBER SIX specifically used for forging aircraft components. 200,000 pound AJAX FORGING ROLL shown at the left and foreground above is designed for pre-rolling blanks for subsequent DROP forgings.

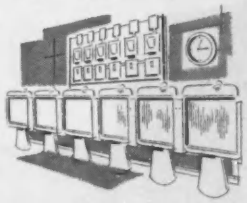
NUMBER ONE universally used in aircraft, automotive, agricultural industries. 20,000 pound AJAX FORGING ROLL shown at the right above is designed for rolling reduced tapered and straight forgings and pre-rolling blanks for subsequent PRESS forgings.

BUILT IN SIX SIZES FROM NUMBER 0 TO NUMBER 6.
ILLUSTRATED AND DESCRIBED IN BULLETIN 91A.

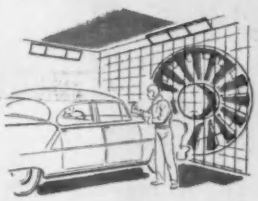
THE AJAX MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
110 S. DEARBORN ST. CHICAGO 3, ILLINOIS
DEWART BUILDING NEW LONDON, CONN.

HARRISON'S RUNNING A TEMPERATURE . . .

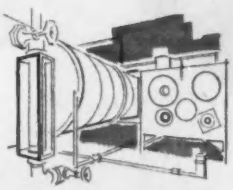
to keep You comfortable!



Testing 6 Harrison radiators in rigorous "life-cycle" test.



Testing a Harrison heater at sub-zero in the cold tunnel.



Testing radiator performance on huge dissipator machines.

The heat's on . . . at Harrison! 100 degrees in the hot tunnel and there isn't any shade! Wind velocity up to 100 miles per hour! Here in this modern inferno, we test the performance of Harrison radiators and air conditioning systems. Hour after hour, scorching air blasts the front of the car. Actually, it's like driving across the desert in the teeth of a high, hot, August wind! Tests like this prove beyond doubt that Harrison radiators and air conditioners are designed to stand up under *every* kind of driving condition. If you have a cooling problem, look to Harrison for the answer.

HARRISON RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N. Y.

HARRISON

TEMPERATURES MADE TO ORDER

Regardless of evasive action

this radar-guided missile

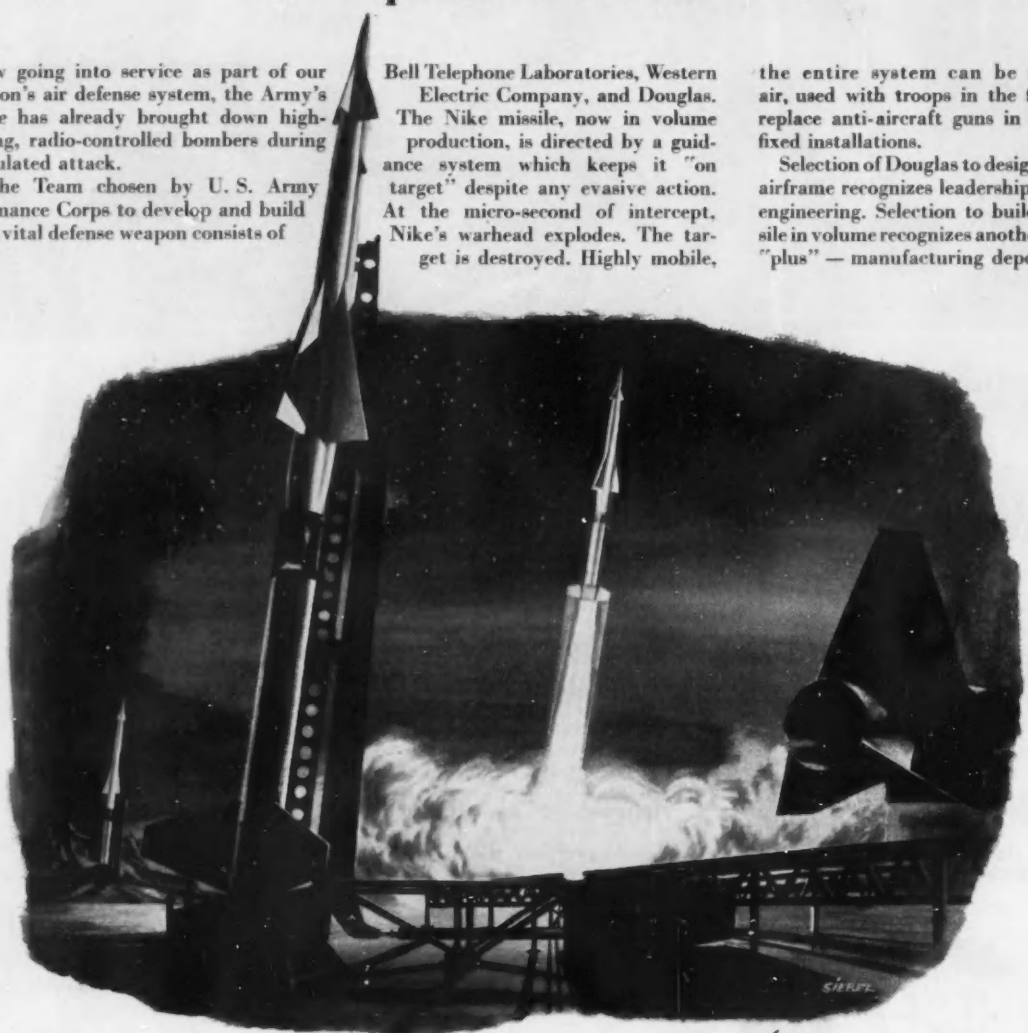
intercepts bombers at supersonic speed

Nike—product of teamwork

Now going into service as part of our nation's air defense system, the Army's *Nike* has already brought down high-flying, radio-controlled bombers during simulated attack.

The Team chosen by U. S. Army Ordnance Corps to develop and build this vital defense weapon consists of Bell Telephone Laboratories, Western Electric Company, and Douglas. The Nike missile, now in volume production, is directed by a guidance system which keeps it "on target" despite any evasive action. At the micro-second of intercept, Nike's warhead explodes. The target is destroyed. Highly mobile, the entire system can be moved by air, used with troops in the field, or to replace anti-aircraft guns in defense of fixed installations.

Selection of Douglas to design the Nike airframe recognizes leadership in missile engineering. Selection to build the missile in volume recognizes another Douglas "plus" — manufacturing dependability.

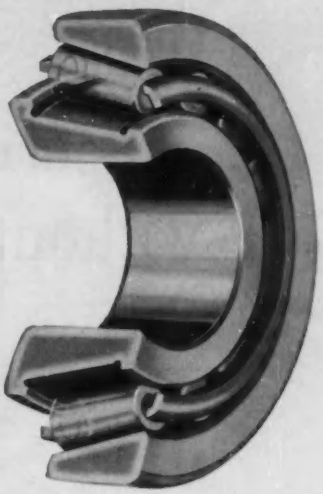


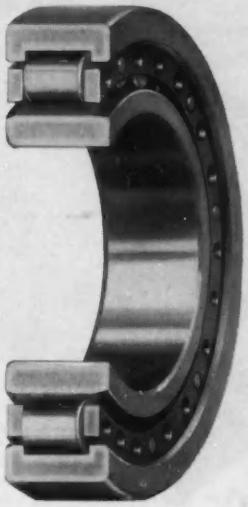
Enlist to fly in the U. S. Air Force

Depend on *DOUGLAS* **First in Aviation**

WHATEVER YOUR ROLLER BEARING APPLICATION

specify BOWER!





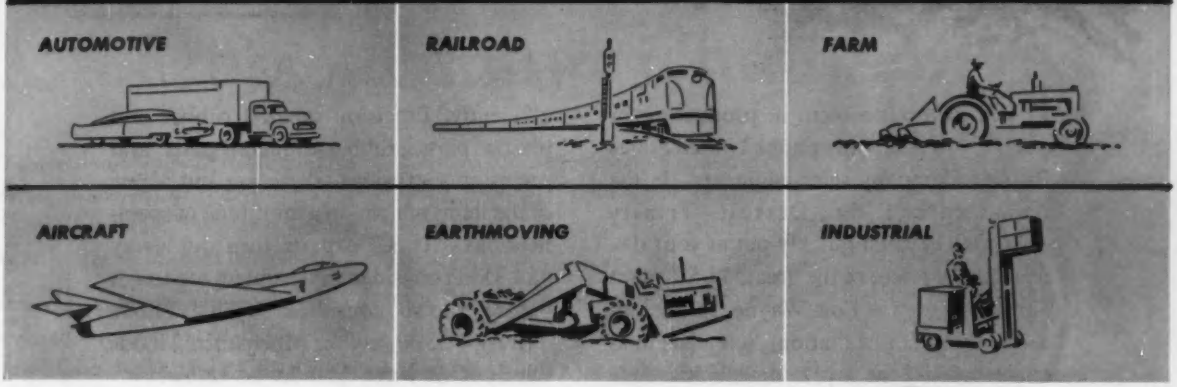
Earthmovers, jet turbine engines, rolling mill equipment, truck axles—you name it! Bower builds a complete line of tapered, straight and journal roller bearings including a size and type to fit *your* product. What's more, these dependable bearings have *proved* themselves in virtually every conceivable type of application. Their built-in quality, skillful engineering and advanced design features provide such important bearing advantages as reduced wear, longer life and lower maintenance requirements. Let a Bower engineer give you full details on the complete Bower line.

BOWER ROLLER BEARING COMPANY
DETROIT 14, MICHIGAN

BOWER TAPERED ROLLER BEARINGS INCORPORATE ADVANCED SPHER-O-HONED DESIGN! Spherically generated roll heads and higher flange with larger, two-zone contact area reduce wear, improve roller alignment and virtually eliminate "end play." This helps hold adjustment and pre-load longer and better. Larger oil groove provides positive lubrication.

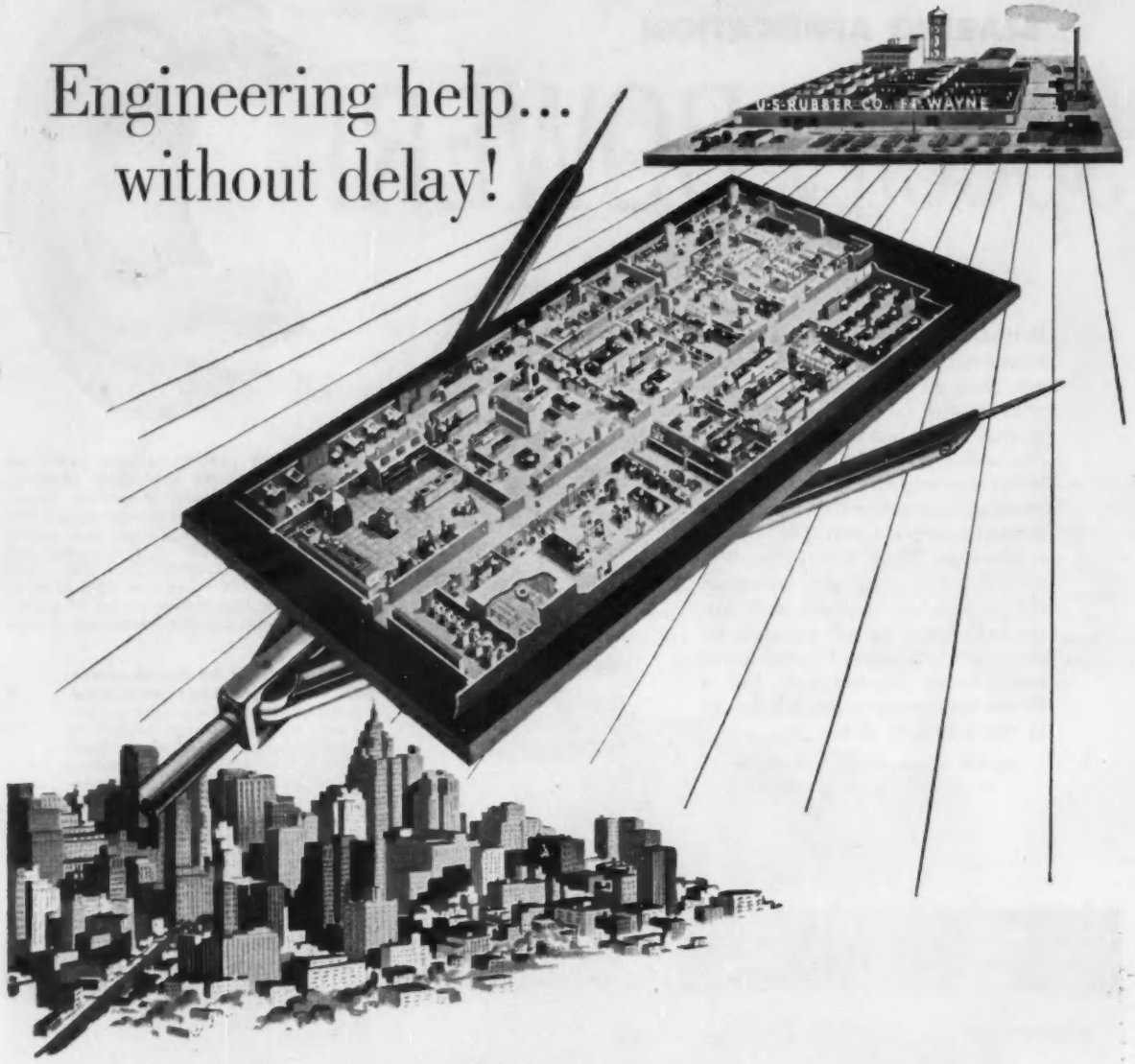
BOWER STRAIGHT ROLLER BEARINGS ARE BUILT TO CARRY MAXIMUM LOADS! Integral two-lip race increases rigidity—keeps rollers in proper alignment at all times. Steel cage allows free movement of rollers between races during normal operation. High-grade alloy-steel rollers and races are precision-ground for quieter, smoother operation.

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS
for every field of transportation and industry



BOWER
ROLLER BEARINGS
SPHER-O-HONED

Engineering help... without delay!



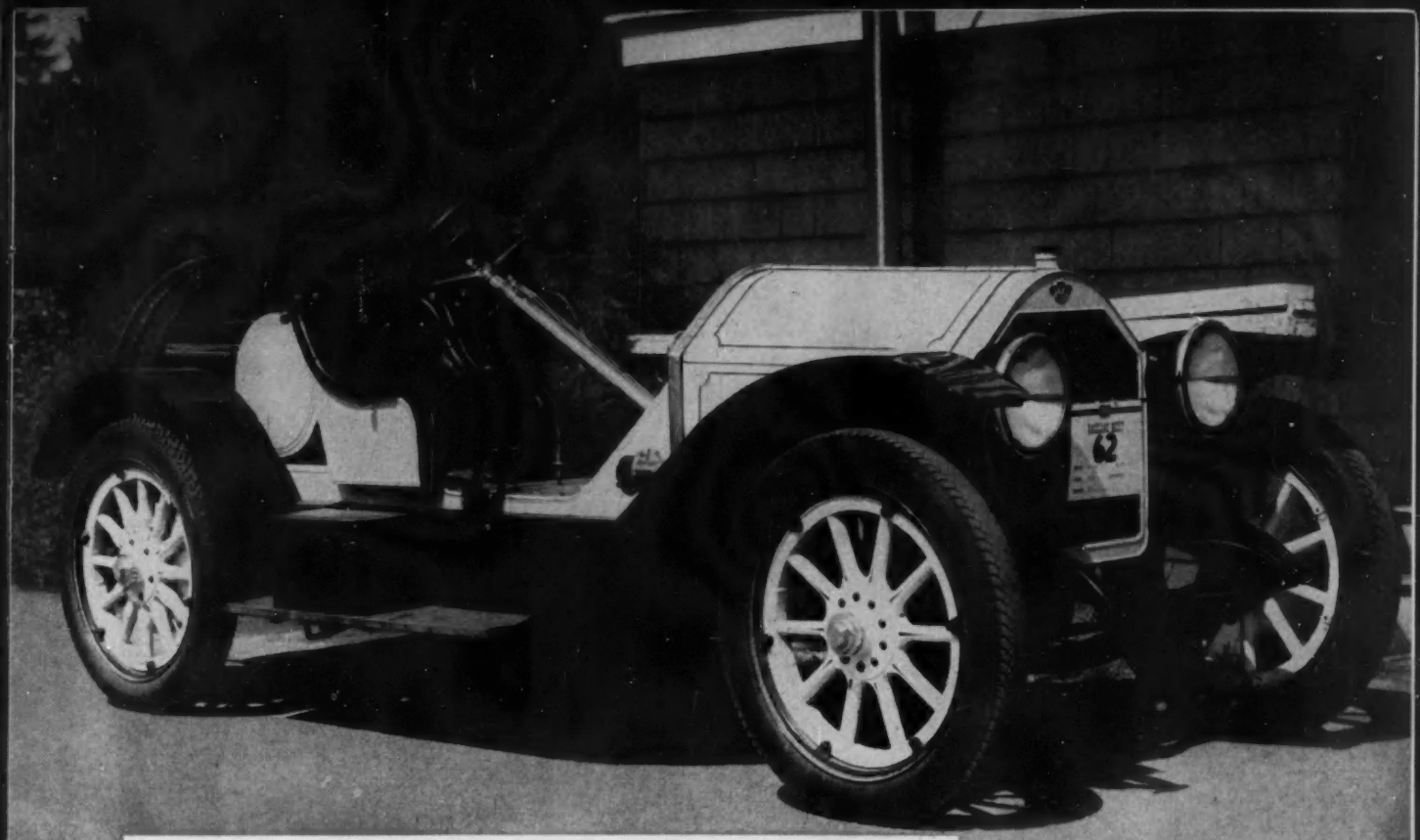
If you have a problem in production or design, you need only phone United States Rubber Company sales engineers—in the New Center Bldg., Detroit—Trinity 4-3500. They can quickly put at your disposal the services of the great "U.S." plant and laboratory at Fort Wayne. In this up-to-the-minute installation, scientists and engineers are at work developing new ways to make your product work more efficiently. Precision molded rubber and plastic parts, rubber-to-metal parts and precision extrusions—these are but a few of the items which—in a multitude of specifications—"U.S." experts turn out every day. Don't consider any problem too tough before you've consulted "U. S." Phone Trinity 4-3500, ask for Mechanical Goods Division, or write the address below.

"U.S." Research perfects it
"U.S." Production builds it

US RUBBER

UNITED STATES RUBBER COMPANY

Automotive Sales, Mechanical Goods Division • New Center Bldg., Detroit 2, Michigan



SEND FOR FREE PRINT

The Bearcat—one of the very few true sports cars built in this country. This 1916 Stutz Series E Bearcat had a top speed of 80 mph, a demoniac speed back in 1916. It had a Wisconsin T-Head four cylinder engine of 4¾ x 5½ bore and stroke, rated at 36.1 hp but developing over 60 hp at only 1500 rpm.

This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free copy, suitable for framing.

Proved dependability keynotes Morse Timing Chain Drives

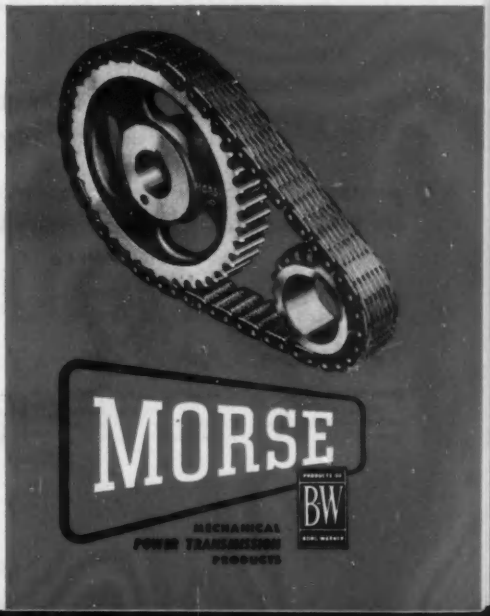
Of the cars now using timing chain drives, twelve out of sixteen—or 74% of those produced, use Morse Timing Chain Drives as original equipment.

Morse is the leading maker of mass-produced, precision-made timing chain drives. Over 58,000,000 of them have given dependable performance in some 116 different makes of cars and trucks.

Rely on Morse for expert engineering service; prompt, on-schedule delivery of parts, too.

Write or call us today. See why it is true that M = TC, Morse means Timing Chains.

MORSE CHAIN COMPANY
7601 Central Avenue
DETROIT 10, MICHIGAN



M=TC

Morse *means* Timing Chains

The New Holland Model 60 Wire-Tie Baler, a heavy-duty machine designed for use on large farms, uses Bundyweld parts like those pictured at right.

How top farm-machine builder gives equipment dependable lifelines

Taking dead aim at target of farm-machine durability, New Holland uses Bundyweld Tubing to assure trouble-free lifelines.

WHY BUNDYWELD IS BETTER TUBING

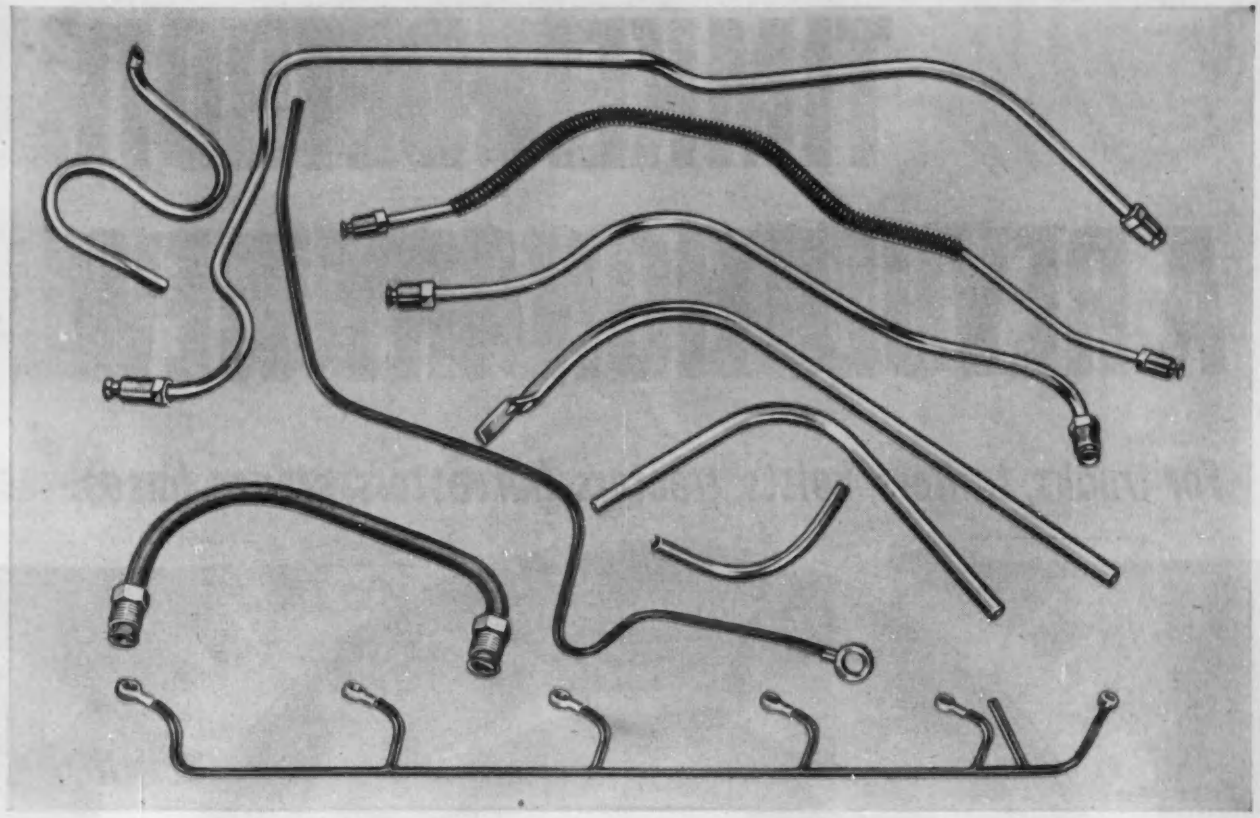
Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.



Leakproof Bundyweld assures unfailing function of oil, gas, and transmission lines, other lifelines. Shown above are just a few samples of the wide variety of tubing parts produced for Bundy customers.

New Holland's Model 80 Wire-Tie Baler is typical of the many carefully engineered farm machines which rely on Bundyweld Tubing for vital gas, oil, transmission lines, other tubing lifelines.

Since farm machinery must stand up under rugged weather, terrain and use conditions, the manufacturer must insist on sturdy, leakproof tubing which can withstand heavy vibration fatigue, punishing wear. *Bundyweld meets these requirements—and more.*

Bundyweld is leakproof by test; thinner walled yet stronger; has high bursting strength; takes easily to standard protective coatings; has high fatigue limit. It's the only tubing double-walled from a single metal strip, copper-brazed throughout 360° of double-walled contact.

Extra dividends: Bundy backs up the world's finest small-diameter tubing with the industry's most technically advanced fabrication facilities; expert engineering assistance; custom-packaging of orders; prompt, on-schedule deliveries. Let us help you with your farm machines, automobiles, trucks, or buses. Call, write, or wire.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN

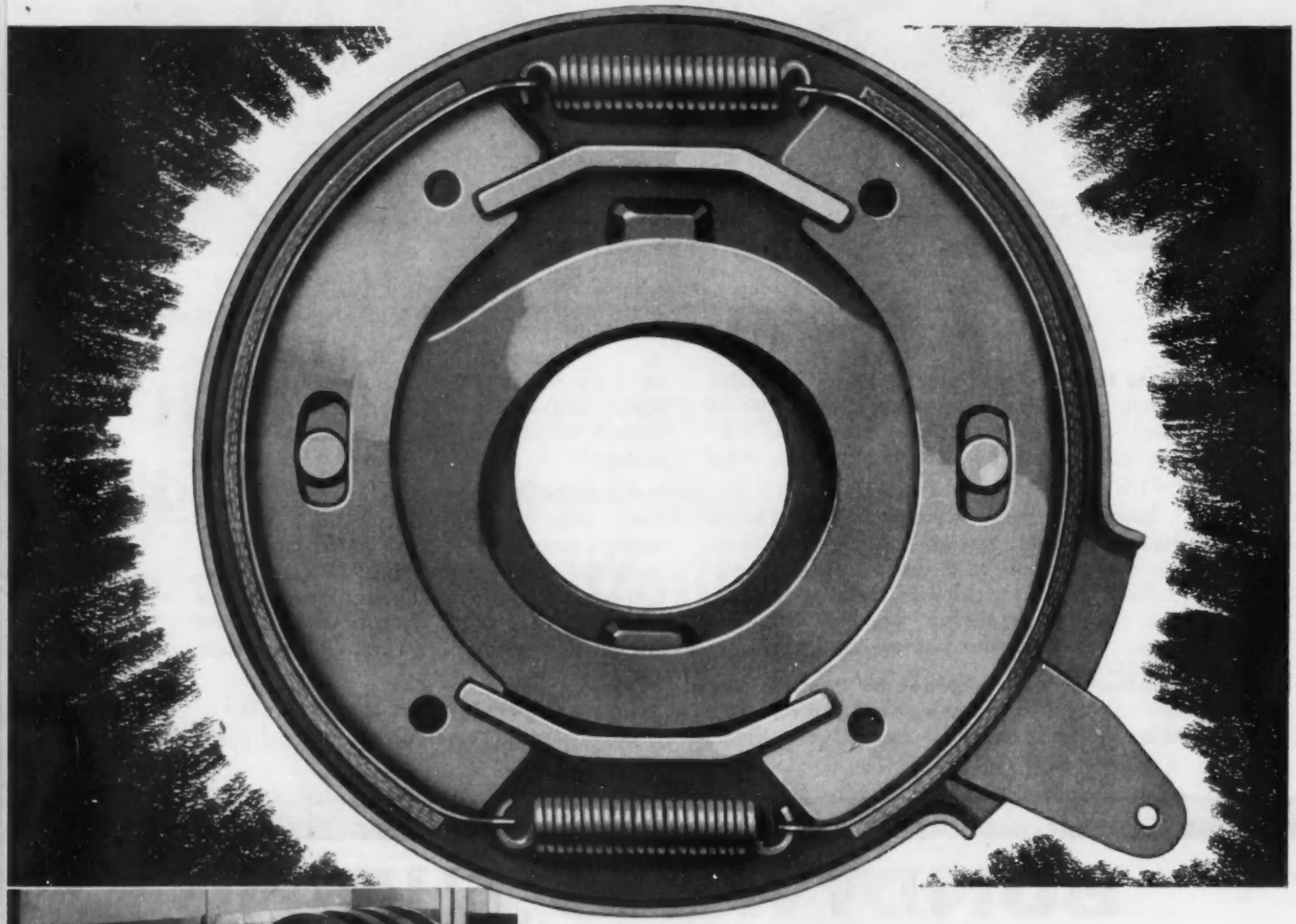
BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Bundy Tubing Distributors and Representatives: *Bridgeport, Conn.:* Korhumel Steel & Aluminum Co., 117 E. Washington St. • *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. E. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.:* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South • *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St. East.
Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

TIMKEN-DETROIT
A REVOLUTIONARY NEW

For trucks, trailers, hoists, tractors, harvesters, cranes, buses,



Pre-proved in "Torture Tests"

Here's where TDA brakes are run through exhaustive tests on brake dynamometers in the world's most exacting "Torture Chamber." New materials and design features are constantly being tested and developed for use in every type of product. Also, field tests are performed on all types of brake applications under every conceivable operating condition.

ANNOUNCES ALL-PURPOSE BRAKE!

shovels, mixers, machinery, etc.

THIS BRAKE ALONE OFFERS YOU THESE 7 ADVANTAGES!

1 **NEW SIMPLICITY!** Only 8 simple parts. Shoes and springs are completely interchangeable. For instance – brake shoes can be "slapped in." Position of the shoes makes no difference . . . it's *impossible* to install them incorrectly. Simplifies stocking – only 6 different parts required to completely replace the brake.

2 **NO LUBRICATION REQUIRED!** Maintenance reduced to the absolute minimum. No skilled help needed because it's "fool proof" to service and install. No inside adjustment necessary.

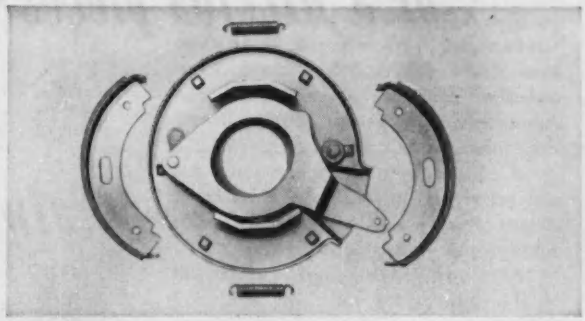
3 **ENCLOSED DESIGN** – protects against dust, dirt, water, contamination. Prolongs brake life, reduces fire hazard.

4 **LIGHTEST WEIGHT!** This new development by TDA is in a class by itself. For example: the 13-inch drum size weighs only 40 lbs. as against 80 lbs. for an ordinary band brake!

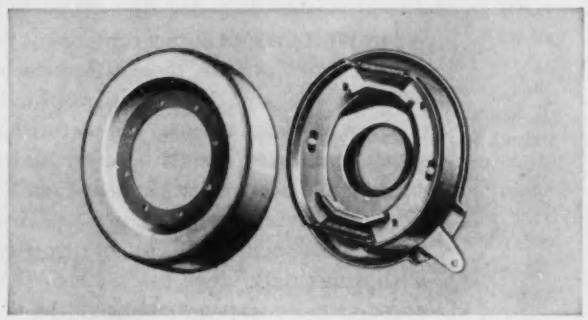
5 **LESS COST!** These brakes use lightweight stamped steel shoes of new design as against ordinary heavy, more costly cast shoes. Wear longer with increased braking power.

6 **NEW BALANCED-TYPE DESIGN!** Exerts equal torque – in both directions. Balanced pressure makes both shoes do same amount of work. Brake linings have uniform wear pattern . . . constant, smooth performance.

7 **FIVE TIMES LONGER BRAKE LINING WEAR,** proved in actual road and work tests. This means less maintenance costs for operators . . . less inventory to stock. For instance: one manufacturer plans to use *three* of these new brakes to replace *five* types now employed.



Look how simple it is! No tricky assembly. Just remove two springs and lift out shoes. Anyone can put it together in minutes. No adjustment of brake required.



Here's the combination that gives this brake its outstanding superiority. Fewer parts to wear, to stock—longer life —less maintenance—lower cost.

FREE! JUST OUT—HOW TDA CAN HELP YOU SOLVE YOUR BRAKING PROBLEMS!

Complete new literature now available on this revolutionary new brake. The result of 50 years of Timken-Detroit engineering experience . . . available in all sizes, for any type of work.

If somewhere in your business there is a special braking problem, big or small, we urge you to call on the ingenuity and vast knowledge of TDA engineers to solve it quickly – at low cost and without obligation. An inquiry on your company letterhead will receive immediate attention. Take advantage of this money-saving service now. Just write Timken-Detroit Brake Division, Ashtabula, Ohio.

TIMKEN *Detroit* **BRAKES**

TIMKEN-DETROIT BRAKE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ASHTABULA, OHIO

The Accepted T D A Standard

TRADE MARK REGISTERED

Cut to *Your* Precision Demands!

When Western Felt cuts a component part to your specifications, piece after piece is a precision-cut part. You want that kind of uniform precision because the performance of *your* product depends upon it. And because of the peculiar properties of wool felt fibres, especially where the more dense types are specified, it can be processed with amazingly close tolerances. Tolerances as close as a few-thousandths of an inch can be supplied when required.

Western Felts are manufactured to the density you require—cut and supplied exactly to your specifications. They resist wear, age and weather...never ravel nor fray. They seal, insulate, absorb sound and vibration, or lubricate...as you wish! Chemically treated, they can be moth-proof, mildew-proof, flame or water resistant.

You name it...specify it...we put the benefits of 54 years of experience back of making a felt component that will meet your specifications. Write today—your inquiry will receive prompt attention.

WESTERN *Felt* **WORKS**

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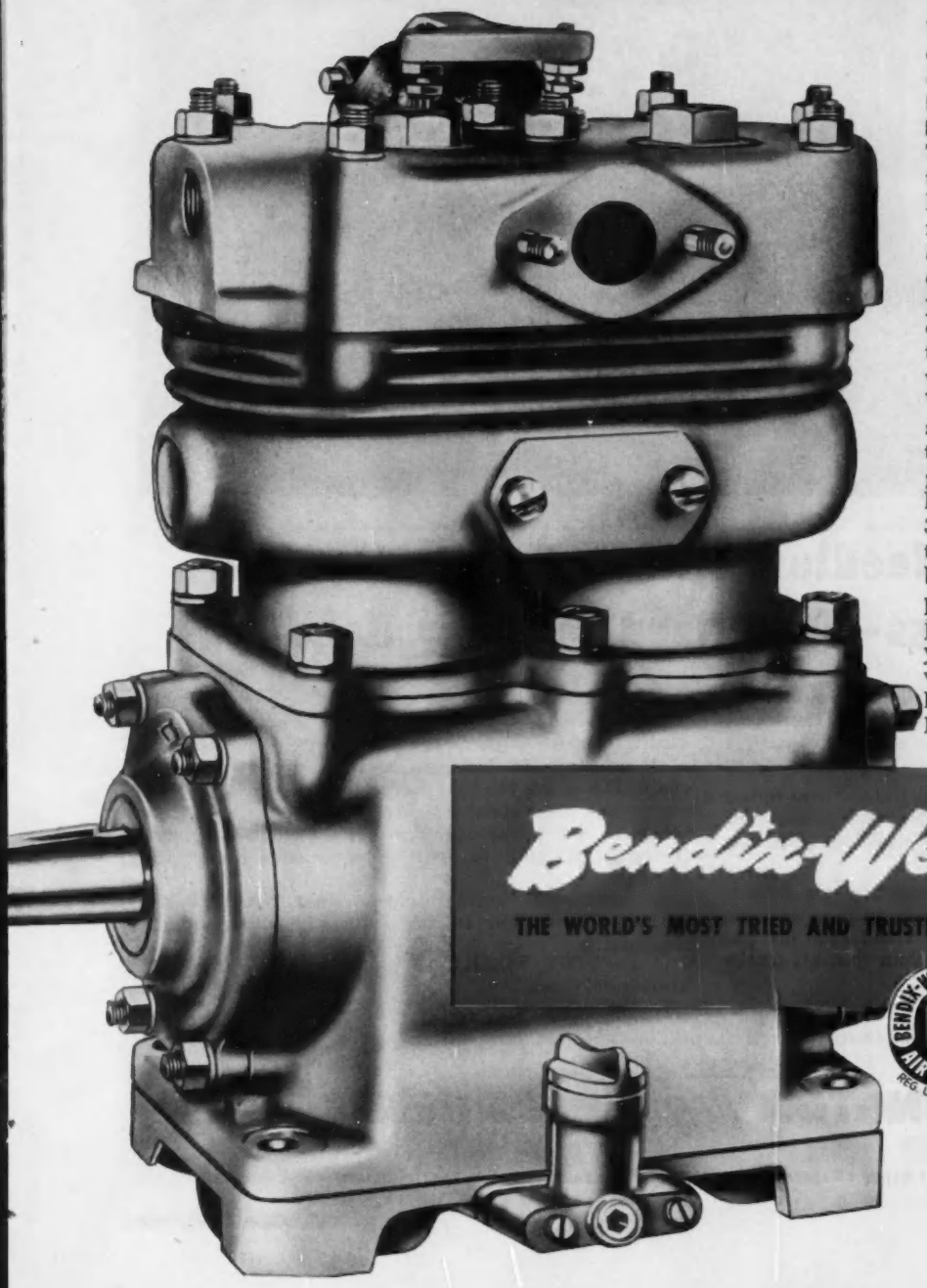
Manufacturers and Cutters of Wool Felt

BIGGEST SELLER

because it's the

BEST PERFORMER!



You're looking at the most widely accepted Air Brake Compressor ever produced for the truck and bus industries—a rugged, reliable Bendix-Westinghouse compressor. This precision-built reciprocating piston compressor is a dependable, long-lived unit which over the years has rolled up *more miles on more installations* than any other compressor ever built. That's mighty important to you. And whether you build, sell or operate trucks or buses, you can put this same unequalled experience to work for you. For into every Bendix-Westinghouse product, from compressors and brake valves right on down to brake chambers and slack adjusters, goes the manufacturing and design know-how gained through more than 30 years of continued leadership in the Air Brake business. That means better, safer, more efficient braking performance on any hauling or transit job. Take advantage of it—be sure your vehicles are equipped with the very best in brakes. Always specify Bendix-Westinghouse—The World's Most Tried and Trusted Air Brakes.

Bendix-Westinghouse

THE WORLD'S MOST TRIED AND TRUSTED **AIR BRAKES**

BENDIX-WESTINGHOUSE AIR BRAKES REG. U.S. PAT. OFF.

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE CO.

General Offices & Factory—Elyria, Ohio
Branches—Berkeley, Calif., and Oklahoma City, Okla.

Typical pallet shipment of Torrington Needle Rollers showing two boxes of 20 cans each strapped to pallet. Open box of cans in foreground.

Torrington Needle Rollers—Vacuum-Packed for Cleanliness—Palletized for Easy Handling

Torrington Needle Rollers by the millions are now being vacuum-packed in tin cans to protect them from dirt, moisture and damage. The foods you eat are not packed with greater care.

This new vacuum pack permits us to send you rollers *dry*—free from oil or grease—so that they can go into your loading machines direct from the can, without time-consuming degreasing.

To make shipping and handling easier, we pack these cans 20 to a carton and strap two cartons to an expendable wooden pallet, for a total weight of about 1500 lbs. per pallet. This makes an easy load for your fork lift trucks to handle and store.

Torrington Needle Rollers deserve this special vacuum pack. They're precision rollers made under statistical quality controls of extraordinary rigor. Every step from alloy selection to polishing and packing is carefully checked to assure you that every can of rollers you receive meets your high standards. And to help you use these rollers to best advantage, Torrington's engineering staff is always available to assist in application design and testing.

Always specify Torrington for precision Needle Rollers in prime condition. In stock for immediate volume shipment.

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Torrington, Conn. South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

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Autos, appliances, transportation or farm equipment . . . if your products require flat-rolled steel, they deserve the best. And it's our obligation to see that you get the very best that 25 years' specialization in flat-rolled steel can provide.

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A UNIT OF

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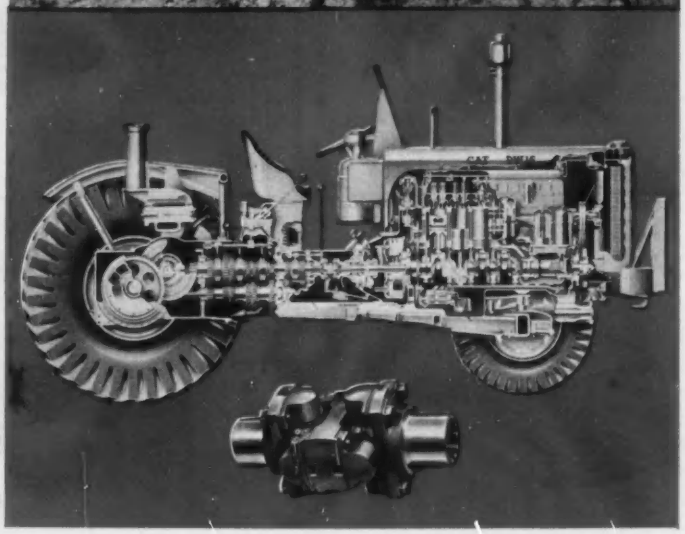
THE NEW CATERPILLAR DW15 TRACTOR

This new 150-horsepower four-wheel tractor is announced by Caterpillar Tractor Co., Peoria, Illinois, in conjunction with the fiftieth anniversary of the crawler tractor, pioneered by Caterpillar. Powered by a Cat six-cylinder Diesel Engine. Standard transmission provides 10 forward speeds and 2 reverse. Designed for principle use with the Cat No. 15 Scraper, No. 10 Scraper and No. 10 Wagon. Includes wagon controls and windrow breakers.

MECHANICS *Roller Bearing* UNIVERSAL JOINTS

An example of how sales begin on the drawing board is shown by this cut-away view of the Caterpillar DW 15 Tractor. Note that every component in the design is well suited to, and contributes competitive advantages to, the complete product. Among the sales-stimulating features of this tractor is the right type and size MECHANICS universal joints. Here at MECHANICS we work closely with our customers during all phases of their power transmission developments. It will pay you to call in a MECHANICS engineer while your product's power train still is in the drawing board stage—to secure size, weight, service and safety advantages.



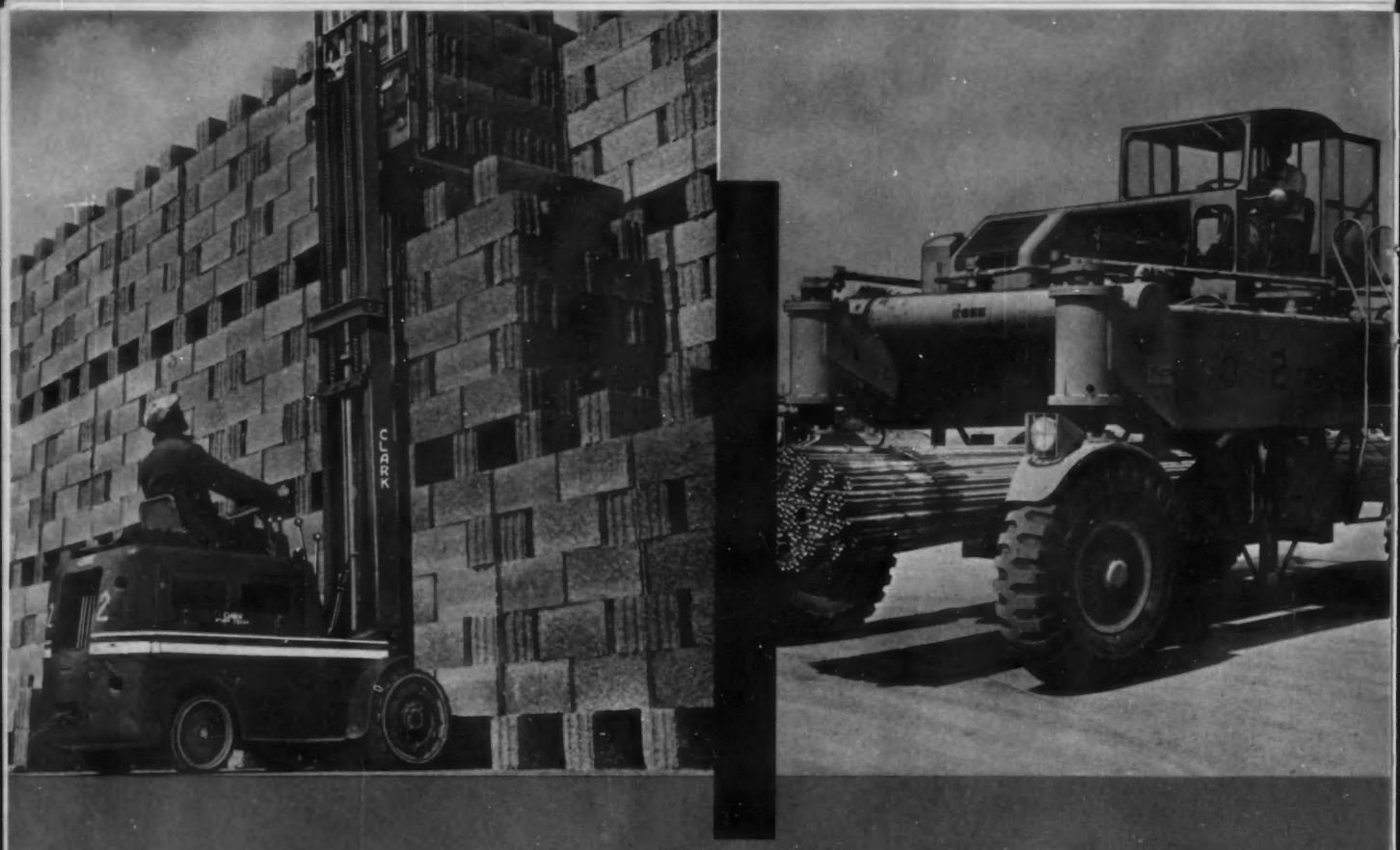
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner
2022 HARRISON AVE. ROCKFORD, ILLINOIS

Precision Made

Finest gearing (the Clark kind) is less a result of special alloys and fine gear making equipment—is rather a product mainly of men's experience, men's know how, men's passion for perfection. Clark gears are another solid proof that it's good business to do business with Clark.

CLARK EQUIPMENT

CLARK EQUIPMENT COMPANY, BUCHANAN, Battle Creek, Jackson, Benton Harbor, Michigan



NO CAPITAL INVESTMENT for your material handling costs when you use

CLARK'S PAY-AS-YOU-GO LEASE PLAN

Without tying up a penny of working capital, put Clark material handling equipment to work for you. With Clark's pay-as-you-go plan, any of Clark's many models and types of handling equipment is available for your immediate use. With no down payment and at a low monthly cost, this lease plan enables you to:

1. Conserve working capital for other essential needs—such as additional inventory, plant expansion and non-leasable capital equipment
2. Pay-as-you-go rental is a totally deductible expense
3. Eliminate trade-in problems and get the benefit of newest equipment.

No outside financing is necessary—you deal directly with your local Clark dealer who will help you determine what equipment best fits your needs. Gas or electric fork trucks, Powrworker hand trucks, tractors and Clark-Ross carriers—all are available on a 3 or 5 year lease.

Let Clark equipment pay for itself as it cuts your handling costs. Call your local Clark dealer for a discussion of the details which will not obligate you in any way.

SEE THE YELLOW PAGES OF YOUR PHONE BOOK FOR THE NAME OF YOUR LOCAL CLARK DEALER

PRODUCTS OF CLARK: TRANSMISSIONS • DRIVING AND STEERING AXLES • AXLE HOUSINGS • TRACTOR DRIVES • LIFT TRUCKS • TOWING TRACTORS • ROSS CARRIERS • POWRWORKER HAND TRUCKS • EXCAVATOR CRANES • TRACTOR SHOVELS • ELECTRIC STEEL CASTINGS • GEARS AND FORGINGS

CLARK EQUIPMENT

Industrial Truck Division
CLARK EQUIPMENT COMPANY
Battle Creek, Michigan

FOR TODAY'S *Push Button* CONVENIENCES—

AMERICAN BOSCH
SMALL ELECTRIC MOTORS

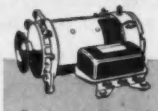
to power—

WINDSHILD WIPERS . SEATS . TOPS . HOODS . WINDOWS . VENTILATORS . STARTERS . HEATERS . TRANSMISSION AND AXLE MECHANISMS

Well built, with characteristic AMERICAN BOSCH precision quality, these high-torque small Motors are sturdy, quiet, powerful and dependable. Just a few of the good reasons they are already in wide use as original equipment. If you have one or a number of small motor requirements in your designs, put the problem up to American Bosch, Springfield 7, Mass.

AMERICAN BOSCH

Automotive and Aviation Magnetos



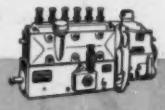
Generators and Regulators

Components for Aircraft Engines

AMERICAN AB BOSCH

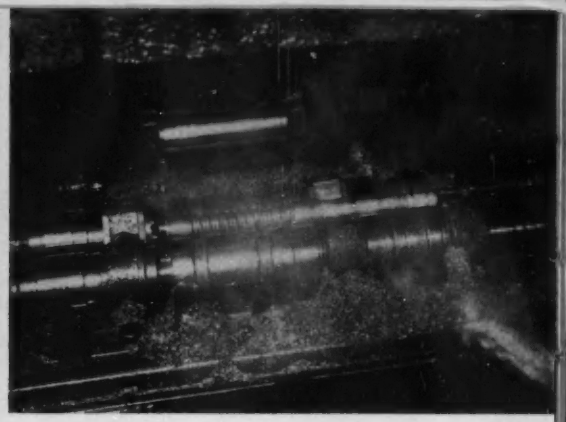
Electric Wipers and Small Motors

Ignition Coils



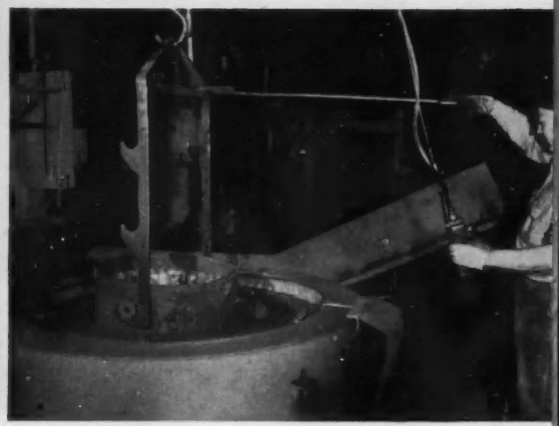
Diesel Fuel Injection Equipment

Torque Testing of completed steering unit. Even the heaviest steering loads require only 3 lbs. pull by the driver of an automobile with power steering. In addition, road shocks are cushioned by the power steering unit.



Worm Shafts are ground to within .0005". Alloy steel must be used for these parts so that they can be quenched in oil with a minimum of distortion to maintain the close tolerances.

Heat Treatment USS CARILLOY steels have the uniformity in response to heat treatment that is so necessary to obtain the high strength, adequate ductility and minimum of distortion required in power steering units.



USS CARILLOY STEELS MINIMIZE DISTORTION

in Power Steering Units for Cars

Power steering units are precision machines. Every part must fit exactly. Parts must be interchangeable. They must be made to finished tolerances as small as .0001". They must be heat treated with minimum distortion.

These rigid requirements dictate the use of accurately controlled *alloy* steels that can be *quenched in oil.* These steels must respond uniformly to heat treatment, time after time, so that many thousands of parts can be made—*all exactly alike.* USS CARILLOY steels are used extensively in power steering units because they help to insure the uniformity that is essential in all critical parts.

CARILLOY steels are giving excellent service daily in a wide variety of precision parts for automobiles, aircraft, trucks, farm equipment, construction machinery, rotating machines, and other applications. These high quality steels meet the toughest requirements known to industry. They can meet yours. For information write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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UNITED STATES STEEL

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offers the new ....

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SP-124

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- A "HOW-TO-USE-IT" BOOK—SAE Blast Cleaning Manual, the work of Division XX—Shot Peening, Iron & Steel Technical Committee, instructs engineers, designers, and shop men in blast cleaning "know how."

- A FIRST COMPLETE STORY—the Manual fully discusses blasting abrasives, blast cleaning machines, production procedures and process specifications; includes 36 illustrations and 3 tables.

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Now! The world's

RED

Eliminates installation

This bright colored Redicoat coating is available on any metal encased National seal. Together with the ground circumference standard on National Oil Seals, Redicoat offers the most perfect and economical metal-to-metal bore sealing available.

Figure 1. Cross section shows Redicoat seal installed in housing. Radial or circumferential scratches as deep as .003" are filled completely. Bore is sealed as Redicoat seal is installed; no drying or "setting" is required.

first pre-cemented oil seal!

REDICOAT OIL SEALS

TRADE MARK

cementing—offers important economies on your production line

Now you can install press fit oil seals that insure a perfect, enduring seal between oil seal and bore as well as oil seal and shaft. You can eliminate danger of cement reaching and damaging sealing surfaces, and you can *completely eliminate cost of cementing on your production line.*

Amazing new National Redicoat is applied at NMB factories. Seals reach you pre-cemented smoothly and evenly all around the circumference of the outer case. The truly negligible additional cost of Redicoat is more than made up by your very real savings in assembly time and materials.

What is Redicoat?

National Redicoat is a material developed and applied by, and available only from, National Motor Bearing. It is dry to the touch, does not pick up dirt, and does not adhere to other seals or containers. It also prevents rust on the area covered.

Upon installation, a microscopic portion of the coating rolls up at the bore's edge (Figure 1) but the majority remains as a tough, stable cement filling all irregularities in the housing bore. Redicoat will last indefinitely even at temperatures −65° to +350° F. The fit is even more perfect than metal-to-metal with a ground outer case surface (as on all regular National seals). Seals may be removed easily, even after prolonged service at 300° F. No special preparations are needed for installation, and no tedious cleaning of the housing bore is required when Redicoat seals are removed and new seals installed.

NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS

NATIONAL MOTOR BEARING CO., INC.
General Offices: Redwood City, Calif.
Plants: Redwood City, Calif.; Van Wert, Ohio

2081

NATIONAL MOTOR BEARING CO., INC., Dept. C
Broadway at National, Redwood City, California

Gentlemen: Please send information on Redicoat Oil Seals as applied to _____ (Type of Product)

Name _____

Company _____

Street _____

City _____ Zone _____ State _____

New "Monarch"

BY MILSCO *America's Leading Seat Specialists*

FOR MANUFACTURERS OF MOBILE EQUIPMENT

No. 344 *With Or Without Fore And Aft Attachment*

★ **4 Point Body Comfort**

The new Milsco "Monarch" features deep cushion comfort with full 4-point body support. Ruggedly built; attractively styled. Designed for stepped-up work efficiency on many types of mobile equipment. (Sold to equipment manufacturers only.) Write for catalog on your company letterhead.

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LAMINATED PLYWOOD BACK AND SEAT | GENUINE OR ARTIFICIAL LEATHER | TUBULAR STEEL FRAME | FOAM RUBBER OR LATEX COVERED SISAL | SPECIAL LONG LIFE COIL SPRINGS | Milsco MILWAUKEE

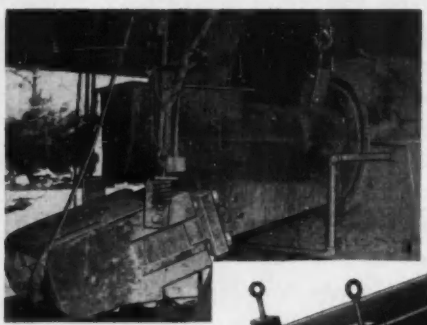
Imperial

THE *Finest* TRACING CLOTH

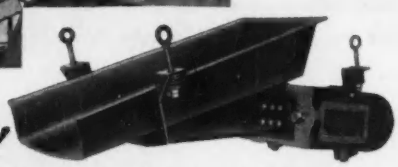
Imperial is known in drafting rooms all over the world as the traditional quality tracing cloth.

With the background of decades of experience, its makers have pioneered in modern improvements to maintain Imperial as the finest tracing cloth made.

Controlled Feeding of Bulk Materials Means Greater Production At Lower Cost



Feeding of pulverized material directly to ball mill speeds production.



SYNTRON

VIBRATORY FEEDERS

Handling most bulk materials—from fine powders to heavy lumps—at instantly controllable rates—Syntron Feeders deliver a constant flow of materials at desired production speeds. Ideal for automatic handling set-ups where cost control is important. Electromagnetic operation—no gears, cams, belts, etc. to wear out.

Write today for complete catalogue data—Free

SYNTRON COMPANY
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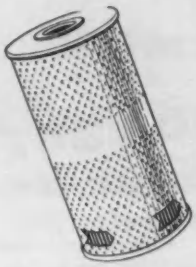
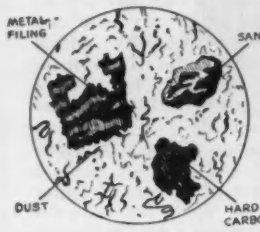


1.

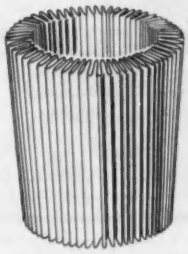
High full-flow rates within practical design dimensions: Purolator's famous "accordion-pleated" Micronic* filter element has up to ten times more filtering area than old-style filters—gives high flow rates in a minimum of space.

2.



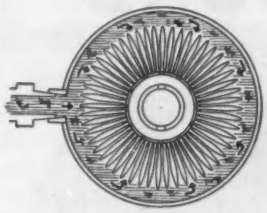
Ultra-micronic filtration: High flow rates are, of course, meaningless unless effective filtration is maintained, too. Electron micrographs prove that the Purolator Micronic filter stops particles down to *submicrons*—.0000039 in.!

3.



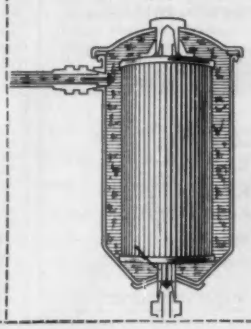
Maximum dirt storage capacity: The pleated design of the Purolator Micronic filter element provides many times more dirt storage space than old-style filters. This important advantage means uniform, efficient performance throughout a long service life.

4.



Minimum pressure drop: With its larger filtering area, the Purolator Micronic filter element introduces a remarkably small pressure drop into the lubricating system . . . permitting pumps of practical size and simple type.

5.



Will not remove or absorb additives: With Purolator Micronic filtration, you keep *all* the oil quality you pay for. The Micronic filter element will not strip additives . . . an important advantage with HD and heat-resistant oils.

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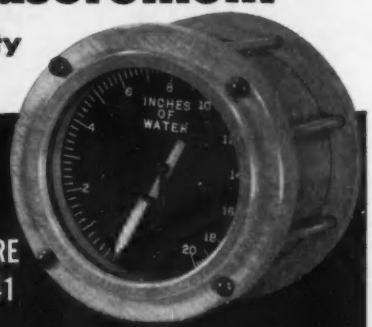

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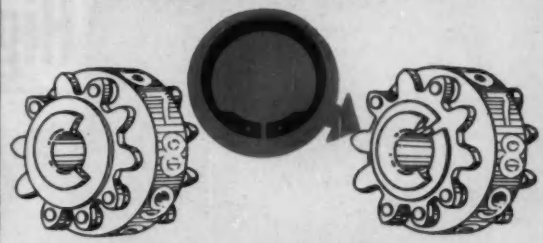

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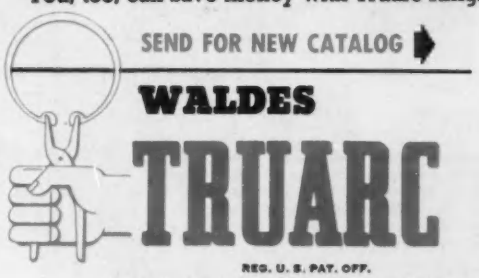

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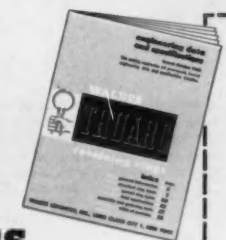

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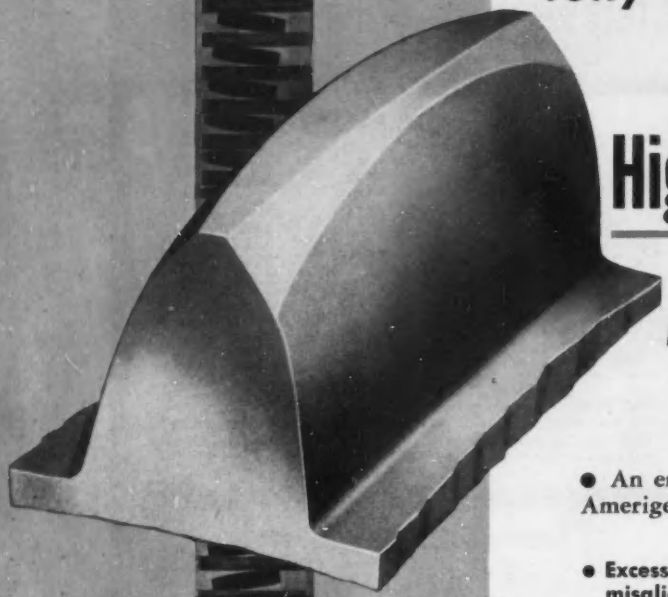

Illustrating Full CycleMisalignment Pattern of Amerigear H.M.C. *Patented Tooth Form.

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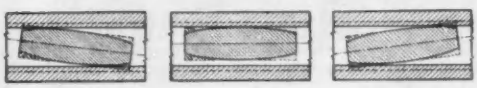
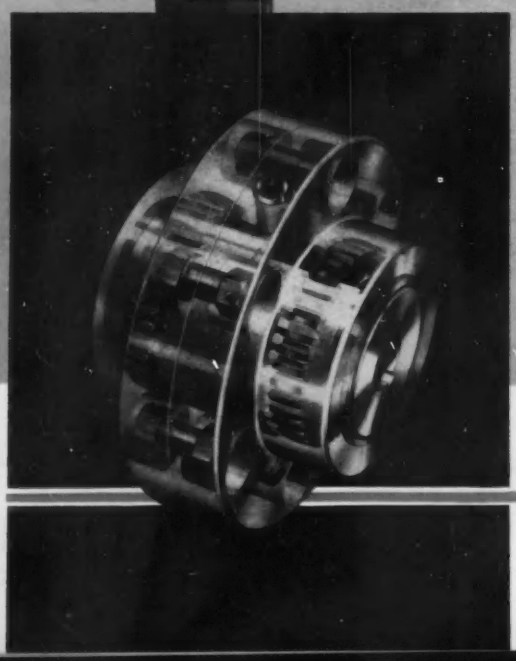
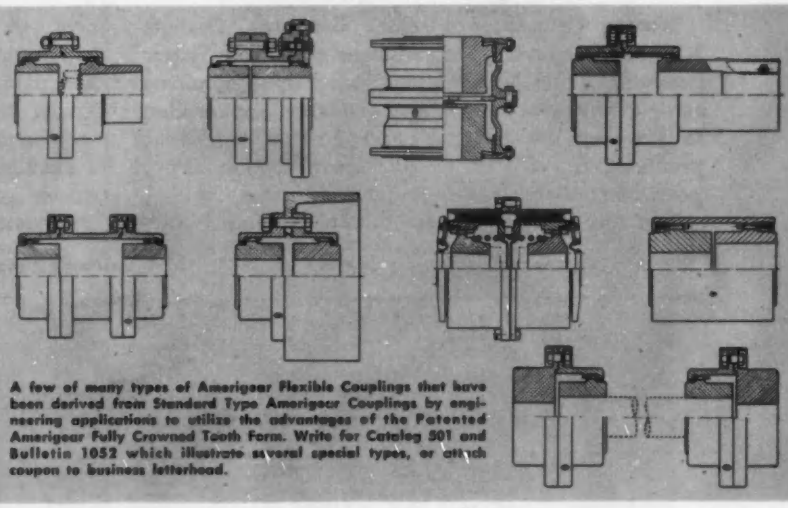


Comparison with gearing of conventional gear-type couplings shows how Patented Amerigear Tooth Form eliminates *tooth end loading* and simultaneously allows for both lateral and angular misalignment. Dotted lines indicate gear teeth of conventional gear couplings.





A few of many types of Amerigear Flexible Couplings that have been derived from Standard Type Amerigear Couplings by engineering applications to utilize the advantages of the Patented Amerigear Fully Crowned Tooth Form. Write for Catalog 501 and Bulletin 1052 which illustrate several special types, or attach coupon to business letterhead.

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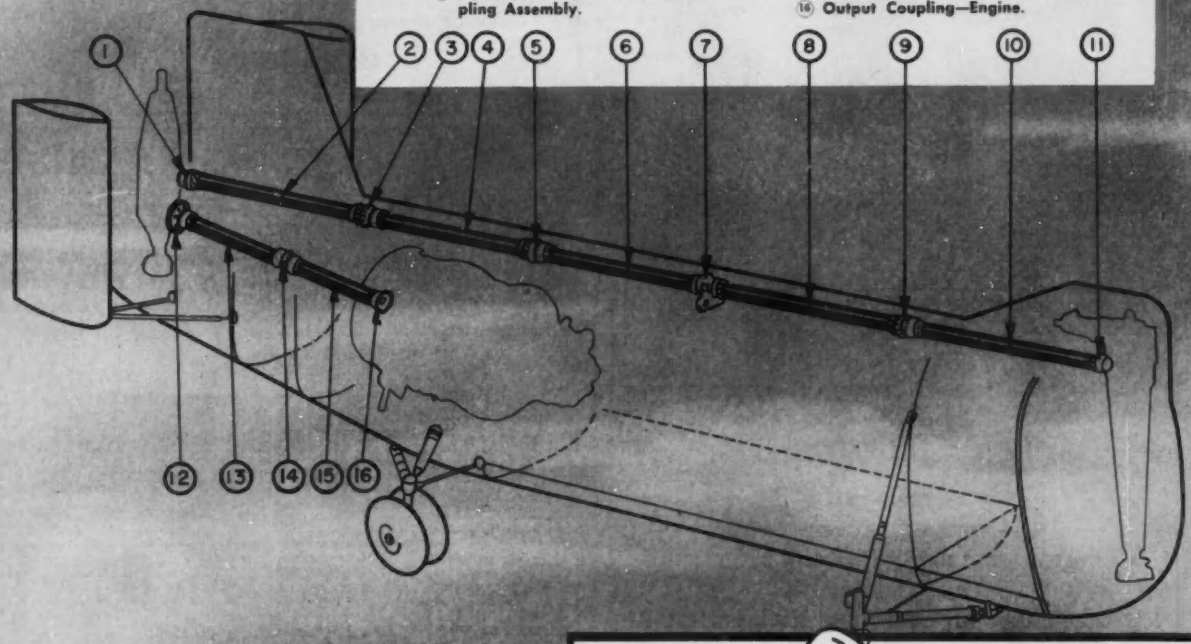
4. Center Section — Aft — Inter-connecting Shaft.
5. Coupling Assembly — Inter-connecting Shaft.
6. Center Section—Inter-connecting Shaft.
7. Hydraulic Pump Drive and Coupling Assembly.
8. Center Section—Forward—Inter-connecting Shaft.
9. Coupling Assembly — Inter-connecting Shaft.
10. Forward Section — Inter-connecting Shaft.
11. Input Coupling — Forward Gear Box.
12. Input Coupling — Aft Gear Box.
13. Aft Section—Input Shaft.
14. Input Shaft Coupling.
15. Forward Section—Input Shaft.
16. Output Coupling—Engine.



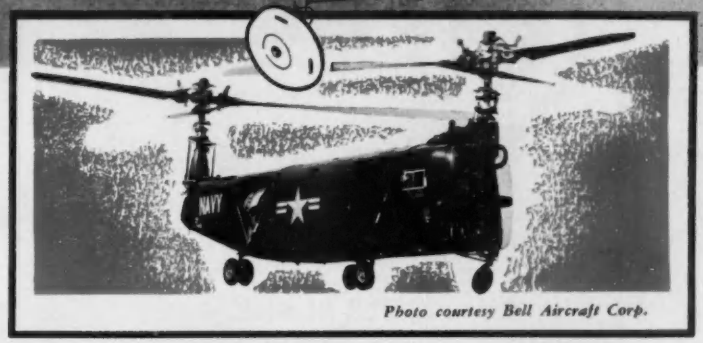


Photo courtesy Bell Aircraft Corp.

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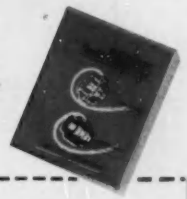

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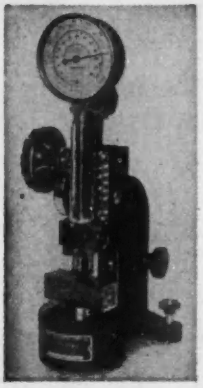

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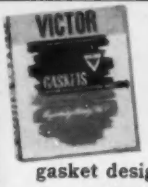

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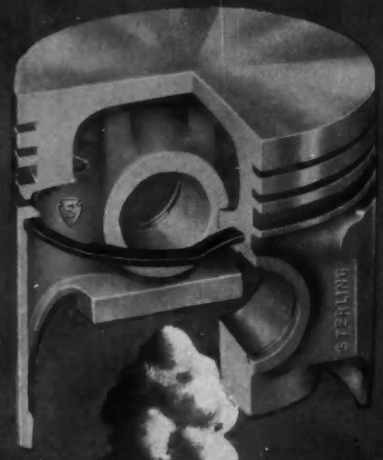

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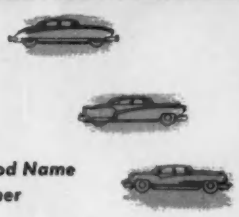

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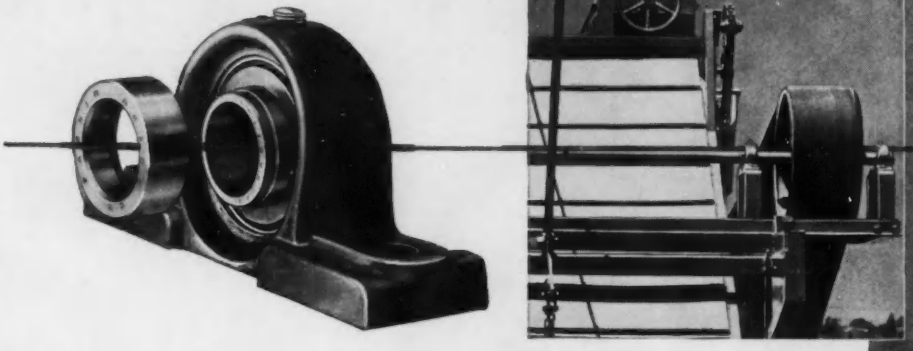
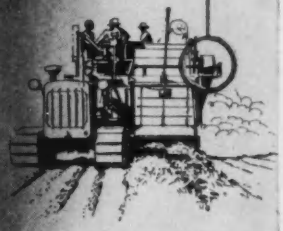
The Engagement Ring makes it positive

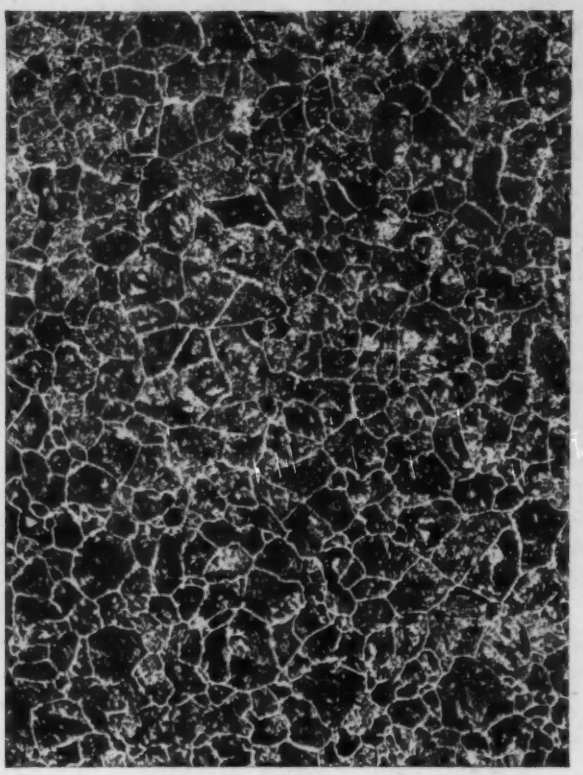




When important shafts on farm machinery and Fafnir Wide Inner Ring Ball Bearings become engaged . . . there's never any question about shaft slippage. The engagement ring, known as the Fafnir originated Self-Locking Collar, makes the union positive beyond a doubt.

In the design of the Self-Locking Collar, you'll find the reason for this positive action. The collar is machined as a mating eccentric cam to the wide inner ring of the bearing . . . and it is counterbored too. A quarter turn of the collar on the inner ring assures positive locking action between bearing and shaft. No set screw, lock nuts or adapters are needed. No adjustments of any kind are necessary and the bearing cannot be cramped or overloaded in mounting.

For straight shaft mounting, the Fafnir Wide Inner Ring Ball Bearing with Self-Locking Collar continues to rate "tops" as a feature of power transmission units. Its positive-engagement, *plus* simplicity-of-mounting, *plus* efficient seals are features that lead to savings in design, assembly and maintenance. Are you taking advantage of them? The Fafnir Bearing Company, New Britain, Conn.



Meet two of the reasons why TIMKEN® forging steels give you uniform, high-quality forgings

THE man on the left helps assure you of uniform composition in every Timken® steel forging bar. With this spectrometer, he can tell the exact composition of a melt in just 40 seconds. Results are flashed back to the furnace so the melter can maintain constant control of the heat analysis up to the instant of pouring.

The photomicrograph at right shows the uniform grain size of the Timken forging steels. Uniform grain size after heat treatment is assured by spectrometric or microscopic examination of every heat. The result—you can be sure that forgings made from Timken forging steels have uniformly high ductility and resistance to impact.

But that's only part of the story. You can hold rejects to a minimum because we condition the steel to fit your particular forging requirements. And you save steel because the good dimensional tolerances of Timken forging steels produce uniform weight multiples with a minimum of steel lost in flashings. You even have fewer furnace adjustments because Timken forging steels respond uniformly to heat treatment.

For help in improving the quality of your forgings and cutting production costs, write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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